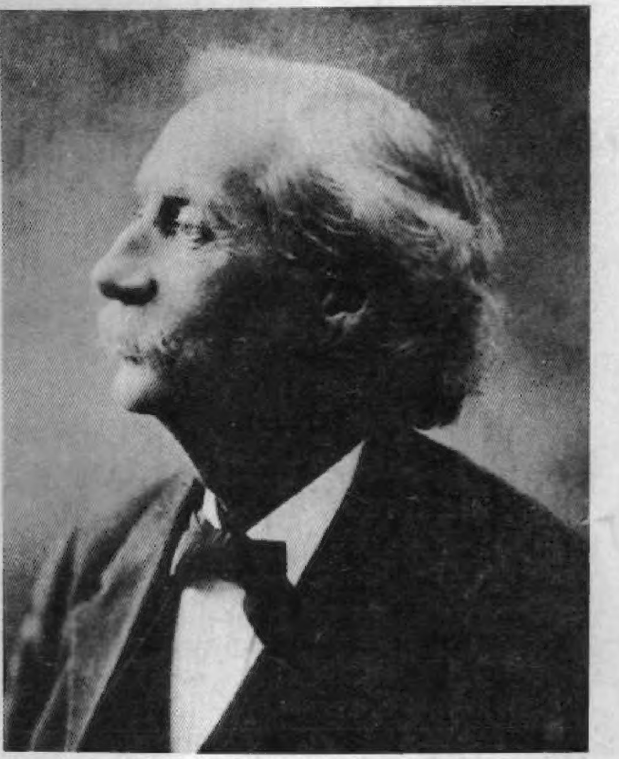
McILVAINEA

OFFICIAL ORGAN OF THE NORTH AMERICAN MYCOLOGICAL ASSOCIATION



Charles McIlvaine

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INTRODUCTION

During the past decade the American amateur mycologist has emerged from eclipse and is now closing the gap between himself and his European counter-part. Until the early sixties no large nation-wide mycological society existed that was solely oriented to the amateur and his problems. The well known Mycological Society of America admits amateurs but places its emphasis on the problems of the professional. Their publication, "Mycologia", prints scientific papers often beyond the ken or interest of the amateur.

Since the Civil War several dedicated men attempted to raise the level of interest of the American amateur mycologist and mycophagist. Among these were Atkinson, Kauffman, and Peck. Other botanists and plant pathologists have since contributed to the popular literature. But the best loved and well read were those amateurs that assumed the herculean task of publishing guides to their great hobby, mushrooms. Examples of these dedicated amateurs are M. E. Hard - the school master, Charles McIlvaine - the engineer and author, and W. S. Thomas - the physician. All of these were well read and respected for decades. "The Field Book of Common Mushrooms" by W. S. Thomas still enjoys widespread use. Perhaps the brightest star in this array is that of Charles McIlvaine for it was he that tested the edibility of many of the fungi he collected and wrote about. He cooked and ate many of the questionable varieties.

The activities of these early mycologists were responsible for several clubs and societies becoming organized in the east, but only the Boston Mycological Club has enjoyed a continuous existence. The New York Mycological Society was organized early but became defunct only to reorganize and grow into a very active group in the past decade. During this same period several large clubs have been formed in the West and numerous small societies are springing up country-wide.

A novice might ask, "Why have Americans remained so far behind the Europeans in this most rewarding hobby?" The answer lies in several areas. First, America was colonized by the English who brought their Anglo-Saxon superstitions with them. A reference to "Ye Slimey Toadey-Stoole" is made in Chaucer as well as several in Shakespeare and Spenser. Secondly the industrial growth of this country tended to group the people in large urban centers and the rapid economical advance made food more available, hence fungi was neither sought after nor desired as a dietary supplement. Later however the great industrial growth caused an influx of central European immigrants from such countries as Italy, Germany, Hungary, Poland, etc. These people brought their love of mushrooms with them. Many soon learned that American fungi were not carbon copies of the well known "Pilz or Houby" of the father-land. The result was a widespread latent interest in mycophagy; particularly in the East around the large manufacturing centers. Todays' second and third generations are forming a great potential for the expansion of the wonderous hobby of mushroom-lore.

The North American Mycological Association and its affiliated local societies are striving to mold this backlog of potential and active amateur mycologists and mycophagists into a cohesive unit.

Twelve years of service have taught the leaders of N.A.M.A. some facts about the American amateur. Almost every member is interested in mycophagy from the more timid that eat only morels and "store-boughten" mushrooms to the most brash who eat certain Amanita and most everything in between. Nearly ninety percent of the members are interested in the photography of mushrooms and more than half of these regularly photograph the fungi they collect with their own cameras. Almost every member is interested in taxonomy to some degree. About fifty percent are interested only in the particular fungus they have on hand or they want a name for a favorite slide or photo. The other fifty percent are a bit more interested and will spend considerable time, money, and labor to track down an elusive mushroom. Of these, only a few get so rabid as to invest in a costly microscope, lab material, and the monographs available. N.A.M.A. would like to raise all of the percentages by interesting everyone in fungal photography on a personal basis, promote the collection and study of the literature as well as attractive fungi, finally to lead the more studious members into specialization and contributions to amateur mycology by the creation of an amateur literature.

The above statements are not just dreams but programs being carried out by European mycological societies and amateurs today! Many of the most sought after authors in Europe are amateurs. A large corps of professional mycologists does not exist in Europe as it does in America. The great universal interest in mycophagy there has created many amateurs that write the literature and do it very well.

A concerted effort by both professional and amateur mycologists in America could go a long way towards the remedy of our present backward situation.

We believe that the relationship between the amateur and professional in America is now at an all time high. The amateur respects the professional for his training and knowledge. The professional in return gets valuable collections and information as well as field expertise from many amateurs in widespread areas. However much remains to be done to improve this relationship. Through many years of training the professional becomes proficient in a language and system that is often as obscure and foreign to the amateur as a Chinese dialect. Since professionals communicate so well in this dialogue, the fact that the amateur understands so little is often overlooked. A few advanced amateurs learn the language of mycology early and apply themselves with remarkable results. We seek therefore, to gain the understanding of both amateur and professional in this vexing problem and to approach the whole structure with awareness and understanding. Specifically the language of mycology might be simplified with reference to taxonomy as it is used by the amateur.

It would be well if those taxonomists who wish to dump all their eggs in one basket (lumpers) and those that wish to smash every last egg down to the smallest possible atom (splitters) could get together and spare the amateur and each other much anguish.

It is entirely possible that a great surge of vigor might be instilled in American amateur mycology in the next decade, providing a sensible course is pursued by all.

The great American ideal of instant success will not work well in mycology. Patience is the watchword. The professionals have spent many long hours learning this lesson and the amateurs must do so in turn or America will never rise above the toadstool picking superstitions of our pilgrim fathers.

Harry S. Knighton

President, N.A.M.A.

THE MAN WHO ATE MUSHROOMS

No figure in the history of mycology is more venerated by mycophagists and amateur mycologists than Charles McIlvaine, author of ONE THOUSAND AMERICAN FUNGI (1900), once commonly called "The Mushroom Bible." McIlvaine's singular and magnificient contribution to the field was that he ate the wild mushrooms he gathered. He proved that a number of mushrooms which had been labeled toxic for decades were actually harmless, and in some instances they were delicious exculents. He gained such a reputation that even today in the midst of a group of mycophagists if one were to ask "Who was the man that ate mushrooms?" there would be instant recognition of McIlvaine. His reputation, however, is not widespread enough to rate a place in any of the standard encyclopedias, and he is known through second-hand sources, largely by quotations and occasional misquotations from his legendary tome.

It was in fact while I was reading Sheila Burnford's delightful celebration of nature some years ago, THE FIELDS OF NOON (1964), that I was first impressed by how far this second-hand knowledge of McIlvaine has spread. However, inasmuch as ours is a two-copies-of-McIlvaine-family, we must admit to certain advantages over Mrs. Burnford who freely admitted to never having seen a copy of ONE THOUSAND AMERICAN FUNGI. Consequently in one of her quotes from a secondary source she used a bastard version of a classic McIlvaine statement. The correct wording is "The writer saved the life of a lovely woman by feeding her upon it [**Marasmius oreades**] when nothing else could be retained; and of another, by feeding **Corprinus micaceus,** after a dangerous operation."

The particular point McIlvaine was trying to make was that certain wild mushrooms are easily digestible: he had introduced them experimentally in the diet of post-operative patients in a Philadelphia hospital where, he claimed, their use was highly successful.

Even among persons familiar with the volume which became his RAISON D'ETRE, there are few who know anything more of McIlvaine the man, of when he lived and worked, other than that ONE THOUSAND AMERICAN FUNGI appeared at the turn of the century.

There is no mention of McIlvaine in BRITTANICA or AMERICANA, nor indeed in AMERICAN MEN OF SCIENCE, but WHO WAS WHO IN AMERICA, 1897-1942 (1943), does offer the information that Charles McIlvaine was born at Springton Farm (Penn Manor of Springton), Chester County, Pennsylvania, on the last day of May 1840.

His father, Abraham Robinson McIlvaine (1804-63), was a successful farmer and a devout Quaker, as well as a prominent politician during the

1830's and 1840's, serving as a Whig in the Pennsylvania state house, as a Presidential Elector (Whig), and as a Congressman for three terms in the 28th, 29th and 30th Congresses (1843-49). During his service in Washington he made a determined stand against the war with Mexico; it is for this that he is remembered today if he is remembered at all. His most memorable speech was delivered on February 4, 1847 when, with considerable courage he rose in the House of Representatives to denounce the President (James Knox Polk) and to brand the United States of America the agressor, saying that "poor and imbecile Mexico" had not the least intention of invading anybody. Congressman McIlvaine saw as the chief purpose of the war the addition of new territory and he expressed opposition to the annexation of "another inch" of what he feared might be slave territory.

Charles McIlvaine, never politically active, was a life-long Republican.

Although the McIlvaines were country gentry, young Charles attended only rural Chester County schools until 1851, and thereafter until 1853 he was a pupil at the Northwest Grammar School in Philadelphia. He was not a university man and took no academic degrees, which was later to prove an embarrassment to the acceptance of his work in mycology.

McIlvaine worked briefly for the East Brandywine & Waynesburg Rail Road (1859-61) and nearly twenty years later was employed (again briefly, 1888-89) as chief engineer for the Jamesville & Washington Rail Road. In the interim period he married Sarah G. McIlvain, who, please note, gained an "e" as well as a husband.

At the onset of the Civil War, he raised a company of volunteers in support of the Union, which he attached to the 97th Regiment of Pennsylvania Volunteers. McIlvaine himself mustered in as Captain and served in several responsible positions on the staffs of Major Generals Alfred H. Terry and Joseph R. Hawley.

In 1863 Captain McIlvaine was appointed Major in the First South Carolina Cavalry (Colored), but declined the promotion on the grounds of ill-health and returned to the family home in Pennsylvania. Exactly whose ill-health was involved here is in doubt: WHO WAS WHO suggests that it was Captain McIlvaine's, although it is certain that his father, the ex-Congressman, was dying in 1863.

As late as 1873-74 McIlvaine still had not settled into an occupation nor had he as yet developed an interest in nature lore; he was, in fact, touring Europe during this very period. According to his own statement, he first began studying and eating mushrooms while "living in the mountains of West Virginia. . .riding on horseback through the dense forests of that great unfenced state," where in the period 1880-85 he "saw on every side luxuriant growths of fungi, so inviting in color, cleanliness and flesh that it occurred [to him] they ought to be eaten." In his own mind he recalled that a mushroom article had appeared in POPULAR SCIENCE MONTHLY, and which had earlier caught his fancy, so he began a search of back issues. Eventually he turned up the May 1877 copy which carried a feature titled "Toadstool Eating" by Julius A. Palmer, Jr. However homely the title, McIlvaine claimed that his re-reading of this piece "was not without immediate reward," but what he in all modesty could not say (and he was a modest man), was that the Palmer article launched the most singular career in all the annals of mycology.

There can be little doubt however that it was because the acknowledged leaders in the halls of academy cast doubt upon the value of his studies, that McIlvaine was ever hesitant to describe himself as a mycologist. I know of no instance in which he so described himself. Others have called him a mycologist, although they too have most often referred to him by his military title, and it may well be that this was by his own preference, as a crutch against the academicians who doubted his fitness. McIlvaine himself listed his occupation as "author," and he is so described on his death certificate, because in his own time he achieved a popular success writing nature lore stories under the pen name, Tobe Hodge.

Two volumes, destined to contribute little to his lasting reputation, were born out of such writings, A LEGEND OF POLECAT HOLLOW (1884) and OUTDOORS, INDOORS AND UP THE CHIMNEY (1906), the latter published just three years before his death. Under his own name he wrote verse, much of it in Scots dialect (none of which ever threatened to tumble Burns from his pinnacle), as well as numerous articles on mycology in scientific journals, and, of course, published ONE THOUSAND AMERICAN FUNGI. There have been but a handful of editions of ONE THOUSAND AMERICAN FUNGI: in 1900, 1902, 1912 and 19 , with the original edition of 1900 appearing under the imprint of Bowen-Merrill Company of Indianapolis, and the later printings coming under the aegis of the same company but with the house name changed to Bobbs-Merrill. The first edition was a limited printing of seven-hundred and fifty numbered copies, each signed by Charles McIlvaine. It is one of the least likely volumes for even the heartiest of mushroom hunters to choose for a field trip as its bulk approximates that of a Manhattan telephone directory in hard covers. Generally one studies McIlvaine at home.

Robert K. MacAdam is credited on the title page with co-authorship, and it is true that he long assisted McIlvaine with his experimentations, but no one seems to doubt that the bulk of the friendly, chatty prose of ONE THOUSAND AMERICAN FUNGI is McIlvaine's.

Charles McIlvaine achieved in ONE THOUSAND AMERICAN FUNGI a master work although his enemies in the Establishment failed to recognize it as such. Typically an unsigned review in THE NATION (November 30, 1902) dismissed the volume with the words "written by an amateur for amateurs." This same carping reviewer compared McIlvaine unfavorably with Nina Marshall, another "amateur," and Professor George Francis Atkinson (1854-1918), a BONA FIDE botanist; in fact the only kindly word expressed was for McIlvaine's "completeness," by which he did not mean lucidity of description but rather the amazing number of mushrooms described. His attack on McIlvaine for allegedly copying most of his study of the **Boleti** from Professor Peck was unfair: McIlvaine was the first to admit that this debt to Peck was indeed great.

Quite early in his career as a mycologist, McIlvaine formed a close working relationship with Professor Charles Horton Peck (1833-1917). Peck himself had an enviable career in science: appointed to the botanical department of the New York State Museum in 1867, the State Legislature in 1883 created the post of State Botanist for him. From 1868 through 1912, in which latter year he was seventy-nine years old, he published an annual report on the fungi of New York State for a total of forty-six reports. There are several instances in which Professor Peck served as a buffer against those who doubted McIlvaine's mycological findings. The bonds of friendship and mutual respect between these two men of science remained until death intervened.

Philadelphia is the city most closely associated with McIlvaines's mycological endeavors, where he formed and for many years headed the Philadelphia Mycology Center. A primary purpose of the Center was to instruct by leading forays in search of edible mushrooms, but McIlvaine also counseled medical men on treating mushroom poisoning because he was, by choice, probably the most frequent victim of mushroom poisons who ever lived to tell the tale; his advice was sought by physicians throughout the country. As a result of his contributions in this area, he was elected to honorary membership in the medical societies of Salem and Gloucester counties in New Jersey. If one were looking for McIlvaine memorabilia, Philadelphia would probably be the best place to search: our 1902 edition was found there and our first edition bears the bookplate of a former owner in Flemington, New Jersey.

It was in Chautauqua County, New York, however, where McIlvaine met and instructed a great cross-section of Americans in the gentle art of gathering wild mushrooms; he was President of the Chautauqua School of Mycology, and there in summer, some of our own grandparents must have learned the basic rules of amateur mycology from the great man himself. McIlvaine asserts that the first-formed mycological club in America was formed in Chautauqua County, although that club, the Westfield Toadstool Club is now apparently defunct, and the Boston Mycological Club is generally conceded to be the oldest continuously active group in the United States, and save for the British Mycological Society, the oldest in the world. The Boston club dates from 1897.

The third locale closely associated with McIlvaine is the small town of Cambridge, Maryland, which in recent years has been several times in the national spotlight as a center of racial unrest. Cambridge is where McIlvaine chose to live during his last years when he was suffering the distresses of arteriosclerosis. He died, a widower without issue, in his sixty-ninth year on Wednesday, August 4, 1909, and a number of people have observed that this was a rather remarkable age for a confirmed eater of wild mushrooms to attain.

It has been said that McIlvaine tested some eight-hundred different varieties of mushrooms for toxic properties by eating them. Considering that each test properly required at least two days for even the safest of mushrooms, and even more time for those which proved to be toxic, it was by any standard a lot of mushrooms to test.

Among the repulsively odiferous mushrooms McIlvaine ate, the members of the family **Phallacaeae** are outstanding: he not only pronounced them edible but good. Fearful things have justly been written about the genus **Amanita;** as for the phalloids, almost with the exception of McIlvaine, only unkind and unflattering words have been penned. And anybody, having once smelled a stinkhorn and observed the insects and blow flies infesting it, comprehends every insultaing word. Professor Miron E. Hard (**Mushrooms Edible and Otherwise,** 1908), a contemporary of McIlvaine, wrote of **Phallus duplicatus,** "A few years ago one of these plants insisted upon growing near my house, where a fence post had formerly been, with the effect of almost driving the family from home. One can hardly imagine so beautiful a plant giving off such an odor." Or of **Phallus Ravenelii,**" one might easily think that all the bad smells in the world had been turned loose" where they are found fruiting. In fact Professor Hard probably expressed the feeling of a majority of mycophagists when he wrote, "The eggs of the **Phallus** and **Mutinus** are said to be very good when fried properly, but my recollection of the odor of the plant has been too vivid for me to try them." Curiously, Professor Hard, failed to mention whoever had said that phalloids were good edibles, but his source was undoubtedly McIlvaine. Dr. William Strugis Thomas (FIELD BOOK OF COMMON MUSHROOMS, 1928, revised 1948), writing about **Mutinus caninus,** says, "McIlvaine is apparently alone in admitting that he had eaten it."

McIlvaine gathered phalloids in the ovum stage, which to those familiar with the mature plants, is nearly as repulsive. He described the eggs as "like bubbles of some thick substance" and adds of **Phallus impudicus,** "In this condition they are very good when fried. They demand to be eaten at this time if at any." **Mutinus caninus** he found" ... gelatinous, tenacious, rather firm, edible and good when sliced and fried."

Among the **Russulas,** there is also to be found a very bad odor - **R. foetens,** or the stinking Russula. McIlvaine found little to say of it that was commendable, and anybody familiar with the odor of this common mushroom will have a vivid memory of its fetid, extremely acrid odor. McIlvaine compares the odor with that of cherry bark, and concludes "The verdict is against it. Cooked it retains its flavor. . .***On two occasions I ate enough to convince me that it was not poisonous."

McIlvaine caused considerable consternation when he ate of another of the **Russulas, R. emetica,** which by its very name suggests that it is poisonous- or at least does not promise to set well on the stomach. He not only ate it but said it was good; that it was one of the very first mushrooms he had ever eaten and that it had been part of his diet for twenty years. McIlvaine's critics insisted that he was misidentifying another harmless member of the genus as **R. emetica,** and so he took his usual recourse and sent off samples to Professor Peck who wrote back, "It seems to be **R. emetica** as you state. It certainly is hot enough for it."

But to return to the foul-smelling mushrooms, let us consider the family **Tricholomataceae.** While there are excellent varieties within the many genera of this family, nevertheless here are to be found two of the most undelicious odors of all mushroomdom - **Tricholoma sulphureum** and **T. saponaceum.** McIlvaine

undertook the task of eating both, and of the former he reported," . . . when quite young **T. sulphureum** is showy and inviting. Its smell is discouraging, its taste forbidding. No amount of cooking removes its unpleasant flavor. I have tried to eat enough of it to test its qualities, but was satisfied after strenous efforts to mark it **INEDIBLE.**" (The solid caps are McIlvaine's.)

Of **T. saponaceum** - the soapy **Tricholoma** - he wrote, "This fungus is not extremely unpleasant when eaten - like **T. sulphureum,** but no one will care to eat it. There is nothing in the flavor to recommend it or to inspire a cultivation of taste for it."

McIlviane had kinder things to say of one of the milk mushrooms - **Lactarius camphoratus.** Members of this group exude a "milk" when the mushroom surface is broken which in appearance is very similar to the sticky substance put out by an injured milkweed stalk. Some members of the genus are considered table delicasies, but **L. camphoratus** is a notable exception due to its strong camphor-like odor. However, McIlvaine defended it, saying "It has high but pleasant flavor. If the flavor is too evident to suit some tastes, it is well to mix milder species with it." Another member of the genus, **L. piperatus,** which smells pleasantly and is not poisonous, was mildly disdained by McIlvaine for its fiery taste which is not always entirely destroyed in cooking. "It has been eaten for many years in most countries, "wrote McIlvaine, "yet a few writers continue to warn against it. . .It is edible and is good food when one is hungry and can not get better. It is best used as an absorbent of gravies."

Odor is one of the major fascinations of wild mushrooms, and of course if they all had odors as disagreeable as those we have been discussing, few would care to gather them and fewer would want to eat them. Many mushrooms in the wild state simply smell as most people think mushrooms should - a nut-like musty odor of earth. But there are those which are branny or fishy. And who can describe the honey-sweet, smoked odor of fresh morels found in the wet dew of a May morning? The odor anise is a common one in several quite diverse varieties of wild mushrooms. And there are times when nothing seems lovelier than the little garlic-flavored **Marasmius scorodonius** added raw to a green salad.

Lentinus lepideus is an anise-scented mushroom that used to be found growing on railroad ties, although it obviously has grown on other dead wood both before the coming of and after the passing of railroads. McIlvaine in his railroading days had ample opportunity to find this mushroom which is delicious and tender when young (it is in fact similar to the oyster mushrooms, and both are sometimes classified as different genera within the family **Tricholomataceae**), but which with age attains something of the texture of the rail ties upon which it may grow. This fact, however, did not halt McIlvaine's gathering of quite aged specimens for food, which he grated, added to soup and pronounced good.

Even today the only way to determine the edibility of a mushroom within the shortest space of time is to eat a small portion of it; the experimentations by eating through which McIlvaine gained fame are still being carried on. And the excellent rules laid down by McIlvaine for testing mushroom edibility, avoiding bravado and based upon caution and common sense, are still as valid today as they were in his own time.

McIlvaine by his own admission poisoned himself often by his experimental testing; he ate a great many specimens which physically he later regretted having eaten. In the course of his testing, however, he proved to his own satisfaction that certain mushrooms with evil reputations such as **Boletus Satanus, B. luridus** and **B. erythropus,** and many others, if thoroughly cooked, were not only harmless but delicious despite their dramatic color changes. When cut the flesh of the lurid **Boleti** within seconds changes from neutral to a startling greenish blue. In a closely related mushroom, the pine cone mushroom or **Strobilomyces floccopus,** the color range passes from neutral gray or white to pink-red-brown-black. It is a delicious mushroom.

Incidentally **S. floccopus** was a favorite edible of McIlvaine and of Julius A. Palmer, Jr., as well - the man who wrote the article which first interested McIlvaine in fungi. We know, however, of more than one recent field guide in which its edibility is disparaged and can only suspect that the authors, like the late Gavin Maxwell in RING OF BRIGHT WATER (1961), actually suffer from a knowledge of how to cook mushrooms properly. The latter almost dismisses the delicious **Cantharellus** as desirable table fare.

Today, despite McIlvaine's experimentations, of the lurid **Boleti** only **B. erythropus** is admitted in some guide books to be wholesome. The others are still described most often as dangerous and even deadly, or at least it will be claimed that they do not taste good. It may be that decades of warning have prejudiced us against them although we personally know people who eat them and agree with McIlvaine's verdict in their favor. It may be the name **Satanus** itself is too forbidding, even though in this regard McIlvaine urged us to keep in mind the fold saying, "The Devil is not as black as he is painted."

However long Captain Charles McIlvaine may be known as the man who ate mushrooms, it is not true that he ate indiscriminately and with wild abandon of the deadly **Amanitas.** Of the seriously toxic Amanitas, we do not find that McIlvaine ate of any except **A. muscaria** - the fly mushroom - and even this he treated with the respect it deserves, eating only a portion "as large as a hazel nut" at one sitting, but enough to cause nausea, dizziness and a hangover. Although McIlvaine was aware that **A. muscaria** was supposed to cause intoxication and sometimes hallucinations, he does not mention such experiences in detail, but merely indicates that the hangover was of mammoth proportions.

McIlvaine was, after all, reasonably cautious. He warned: "While species which contain deadly poisons are few, their individuals are produced in great number. Nicety in distinguishing their botanic variance from edible species closely resembling them is necessary. No charm will detect the poison. Eating toadstools before their certain identification as belonging to edible species, is neither bravery nor common sense. The amateur should go slow."

There is nothing amazing about the scientific data in McIlvaine's work, except perhaps the quantity of it. Still ONE THOUSAND AMERICAN FUNGI is probably not anybody's favorite volume for searching out minute scientific detail. We have in our library perhaps a hundred other books, lighter in weight for the most part, wherein such information may be found. Rather, one reads McIlvaine for sheer delight.

At least I would like to think that McIlvaine knew he was not writing a classroom textbook for budding botanists. He expressed regret in his preface that he had had to cut 50,000 words from the text to satisfy the publisher. But in his unhurried prose which remains he expressed a hope that mycology would someday produce its own Izaak Walton to glorify the "gentle art" of mushrooming.

Unless McIlvaine had no understanding of his purpose in life at all, he must surely have realized that what he had written in his **magnum opus** was a chat, a gossip upon the homely but often exciting art of gathering wild mushrooms, Both Walton and McIlvaine mastered only an ordinary prose style, and yet fishermen would not be lost if Walton had never written THE COMPLEAT ANGLER. That is because Walton's achievement was not to write a handbook, but an attempt to express the SPIRIT of angling. This, I think, McIlvaine also consciously attempted for the good of the souls of all mushroomers. It is doubtful, considering the cruel reception his book received in certain quarters, whether he ever knew how successful he had been in emulating a seemingly uncomplicated old man who went fishing within the shadow of Winchester Cathedral and who has long lain buried within its precincts not far from the final resting place of Jane Austen, a very great writer indeed.

WATLING PAPERS

This series of papers is based on the hand-out notes given to students attending Dr. Watling's one week field course in higher fungi which is held annually in Scotland; because they normally follow a series of lectures, many sections are in abbreviated form. The students attending the course range in age from high school seniors and college students to interested amateurs and biology teachers. A course for more experienced persons runs concurrently with this introductory one.

The notes have been modified in order to allow those not attending the lectures to understand the history and development of the study of higher fungi and the methods employed in examining mushrooms and toadstools. The notes have been formulated to stimulate interest, investigation, and to indicate mycology is not such a chaotic mixture of "facts and latin names" as might be at first supposed. Although the agariocologist does not really require to know about all fungi in general, the notes have been compiled with the belief that a greater interest can be stimulated in the agarics by introducing a slightly wider field than normally adopted for mushroom-pickers.

INTRODUCTION

The Fungi, now considered to be a rather heterogeneous group of organisms are classified as part of the Thallophyta - those primitive plants with a thallus, i.e., no differentiation into root, stem, and leaf, and which is unicellular or multicellular, consisting of branched or unbranched filaments or more or less flattened ribbon-shaped structures.

Are fungi only green plants without chlorophyll?

No! Some colorless plants are in fact found in our floras, e.g. parasites such as **Cuscuta** and **Lathraea** and mycorrhizal orchids such as **Neottia.**

Are fungi algae without chlorophyll?

No! Some colorless algae do however exist, e.g. **Dunaniella.**

Algae are to fungi as follows: photosynthetic as to non-photosynthetic; cellulose in the walls of algae as to chitin in the walls of most fungi.

Green, yellow-green, brown and red algae are to fungi as blue green algae are to bacteria.

Fungi includes: mushrooms, toadstools, shelf fungi, puffballs, etc. etc.
molds, mildews, etc.
rusts, smuts, bunts, etc.
yeasts, etc.

They are simply organized plants made up of cellular filaments known as hyphae (mycelium), lacking specialized pigments for carrying out photosynthesis, reproducing sexually, and/or asexually with the formation of spores which are often produced in enormous numbers. e.g. 16×10^{13} for a puff-ball 24 cm. in diameter.

FUNGI may be saprophytes of parasites

May decompose plant and animal residues thereby leading to an increase in soil structure and fertility.

May cause plant or animal diseases e.g. peach leaf curl, ringworm of animals.

May form mycorrhiza, a rhizophere, a rhizoplane or a phyllosphere with higher plants.

May decay food, fabrics, etc.

Many are utilized in brewing, baking and production of organic chemicals e.g. citric acid, antibiotics and drugs (hallucinogenic fungi).

See "MUSHROOMS MOLDS and MIRACLES" by Lucy Kavalar, 1965 ($6.50).

CLASSIFICATION

"Dividing-lines are the creation of man".

The facts on which the classification of fungi is based are in some cases arbitrary whilst others are founded on hard fact. Nevertheless the interpretation of information is always subject to bias and certainly does not take into account all possible variation. Classification should be taken as a guiding line not as gospel! Exceptions to the generalizations occur and unfortunately take up a lot of time and affect the end product.

Classification is dependent on man; a series of objects can be classed into different groups in many different ways. e.g. pictures can be grouped: a) on the artist b) on the painting medium c) on the size of the frame, etc.

One can obtain distorted ideas on a group of organisms if material from only limited areas is studied. The classification of the fungi was almost completely founded on West European material. The basic plan was then expanded to incorporate new finds from the New World and the Tropics. Even now the majority of tropical countries are largely unexplored and there is little doubt that radical changes will be required in the future. However certain fundamental concepts have been incorporated into the classification and have been retained.

The three major groups of fungi are:

1) Basidiomycetes - 'Basidium' fungi
2) Ascomycetes - 'Ascus' fungi
3) Phycomycetes - 'Algal' fungi

Two further major groups of fungi are incorporated into the basic classification:

a) Deuteromycetes - Fungi Imperfecti i.e. Lacking perfect state.
b) Myxomycetes or Mycetozoa - Slime fungi or slime animals (Slime mold)

Suggested general texts:

E. A. Gauman, THE FUNGI, English transl., London 1952

E. A. Bessey, MORPHOLOGY and TAXONOMY of the FUNGI, Toronto 1953 ($15.00)

C. J. Alexopoulous, INTRODUCTORY MYCOLOGY 1952 ($12.95)

Mycetes --- a fungus, from the Greek for sponge or mucus.

Mycena is a group of agarics and Mycenae is the land about Argos (See Homer)

The Basidiomycetes can be split in different ways depending on the emphasis placed on certain characters by a given author. Thus we have the following systems which have been adopted in the books the amateur may come across.

(A) Homo-basidiomycetes: From the Greek for same-basidium i.e. basidium lacking septa.
Hetero-basidiomycetes: From the Greek for different-basidium i.e. basidium separable into different cells; longitudinally or transversly divided or developing as two arms.

(B) Hemi-basidiomycetes: From the Greek for half, e.g. Ustilaginales and Uredinales.
Hymeno-mycetes: From the Greek for membrane, e.g. Aphyll-ophorales, Tremellales and Agaricales in their widest sense. Basidia born in a hymenium.
Gastro-mycetes: From the Greek for belly, e.g. puffballs, earthballs, earth stars. Basidia borne within the fruit-body or carpophore.

(C) Hemi-basidiomycetes: From the Greek for half, Ustilaginales, basidia and basidiospores degenerate.
Proto - From the Greek for first, Uredinales and Tremellales.
Eu - From the Greek for truly or Auto - From the Greek for self, equals Agaricales and Aphyllophorales in the wide sense, and the Gastromycetes.

The Hymenomycetes is composed of two groups according to many authors and is split thus:

(A) Eu-homobasidineae - Agaricales and Aphyllophorales in the wide sense and Gastromycetes.

(B) Exobasidineae - Exobasidium, Exo-based on the Greek for out of or external.

In order to cover some of the structures outlined in the text, students are referred to the following figures in "GLOSSARY of MYCOLOGY" by W. H. Snell and E. Dick, Harvard Univ. Press 1957:

Basidium Plate IX, fig. 6 - this is very schematic and does not represent the structure as seen in nature.

Agarics, fleshy fungi with a hymenium distributed on the sides of the gills or lamellae - agaricoid, Plate VI, fig. 1-3 incl. Sections showing gill-shape, Plate I (in early works all were placed in Agaricaceae).

Boletes, fleshy fungi with hymenium lining tubes (in early works classified with the polypores but differ markedly in their fleshy, putrescent fruit-body) Plate II fig. 2 and Plate I fig. 3 & 8, showing sections of tubes. (boletoid). Polypores, woody fungi with hymenium lining long or short tubes. (poroid). Plate V, fig. 8-10; Plate III, fig. 1-5. All were formerly placed in the family Polyporaceae.

Hydnums, toothed fungi or hedgehog fungi with hymenium covering teeth or spines; fruit-body either stipitate or resupinate, see below (all species formerly classified in the family Hydnaceae).

Fairy club-fungi with hymenium covering simple or branched club-shaped structures; hymenium distributed over all friut-body or very little differentiation into stem, etc. i.e. amphigenous (formerly all classified in the family Clavariaceae).

Resupinate - a general term applied to apileate members of the Aphyllophorales. Fungi where the lower surface (the cap) is attached to the substratum and the upper surface developes the hymenium, where those with toothed surfaces are

excluded, constitutes the former family Thelephoraceae.

Heterobasidiomycetes, excluding Rusts, Smuts, and Bunts, are usually jelly-like when moist; easily seperated into three distinct groups based on basidium morphology:

1. basidium longitudinally septate and when seen from above resembling a hot-crossed bun -- Tremellaceae
2. basidium transversely septate; basidiospores developing at different levels and pushing up to a common level by elongation of the sterigmata -- Auriculariaceae
3. basidium resembling a tuning-fork in shape and consistently producing only two spores. -- Dacrymycetaceae

In Gastermycetes the basidium often bears more than four spores, and the spores are symmetrically placed on the sterigmata, or if asymmetric then the spores appear to be sessile or on very much thickened sterigmata.

1. Puff-balls & Earth-stars, Lycoperadales often with a soft membrane which forces spores out of the fruit-body when pressed inward.
2. Earth balls, Sclerodermatales with a thick outer skin which cracks and breaks.
3. Birds Nest Fungi, Nidulariales so-called because of their resemblence to a bird's nest; the peridioles containing the spores resemble eggs within the nest.
4. Stinkhorns, Phalles a group of often outrageously shaped and/or colored fungi, many with an offensive odor.
5. False truffles, see below.

HYPOGEOUS FUNGI

ASCUS ASCOMYCOTINA	BASIDIUM BASIDIOMYCOTINA	RESTING 'SPORE'
Below soil surface Tuberales Elaphomycetales	Below soil Hymenogasterales False truffles	Below soil surface Endogone Phycomycete

ASCOMYCETES includes three artifical, though convenient groups:

Pyrenomycetes, Discomycetes, and Plectomycetes i.e. flask fungi, cup fungi, and those fungi with a rudimentary fruit-body.

Differences in the way the fruit-body develops and the differences in the wall structure of the ascus are used to separate the Ascomycetes into fairly natural units. Examples of characters are: Uni - or Bitunicate asci; Operculate or inoperculate asci, the type of operculum in the ascus when present - slit e.g. **Ascozonus;** true operculum e.g. **Peziza,** trap door with hinge e.g. **Sarcoscypha.** The development and origin of the sterile cells (paraphyses) which separate the asci when the fungus is mature is also an important character.

LICHENS. The majority of the lichens are a symbiotic relationship between an alga and an ascomycetous fungus. The lichens can, with a little modification be housed in the existing scheme of classification of the Ascomycetes. Some lichens have a perethical fruit-body but the greatest number produce an apothecium. However, please note the presence in our floras of a few Basidiomycetous lichens, e.g. **Coriscium** and **Botrydina** with **Omphalina luteolilacina** and **O. luteovitellina** as their perfect stages. Phycomycetous fungus/alga relationships are also known.

PHYCOMYCETES etc. Not further dealt with here. The student is referred to the texts already indicated.

NOMENCLATURE see International Code of Botanical Nomenclature, and G. R. Bisby "Introduction to the Taxonomy and Nomenclature of Fungi", Commonwealth Mycological Institute, Kew, England. 1953.

The main divisions adopted in nomenclature, in order of importance, are as follows:

– Mycotina
– mycota Division
– mycetes sub-division
– ales order
– aceae family

The epithet is the second name of a fungus.

The epithet when tied to a generic name makes the species name e.g. **Amanita muscaria, Agaricus bisporus,** etc.

Epithets often assist in remembering one of the characters of that species:

a) habitats etc. see ecology.
b) edibility e.g. **Morchella esculenta, Lactarius deliciosus.**
c) size e.g. **Calvatia gigantea, Nolanea minuta.**
d) shape e.g. **Stropharia semiglobata, Cantharellula umbonata.**
e) color e.g. **Bolbitius vitellinus, Russula rubra.**
f) texture e.g. **Pholiota squarrosa, Coprinus flocculosus.**
g) odor & taste e.g. **Lactarius camphoratus** and **Panellus stipticus.**
h) resembling others e.g. **Amanita phalloides, Cortinarius pseudosalor.**

An epithet may be named after a person e.g. **Melanophyllum eyrei** – (note the lower case for a person's name when incorporated into a species name).

Starting point dates for classification of the fungi are:

a) Lichens and Myxomycetes; C. Linnaeus, Species Plantarum, May 1, 1753.
b) Gasteromycetes, Rusts, and Smuts; C. H. Persoon, Synopsis Methodica Fungorum, December 31, 1801.
c) All other groups, including Agaricales; E. Fries, Systema Mycologicum January 1, 1821.

COLLECTING AND PRESERVATION

a) Collecting

For the serious study of fungi it is always better to collect only a few specimens **well** than a large range of specimens **badly.**

Collect specimens in plastic containers or 'twists' of waxed-paper.

Boxes are preferable for the smaller delicate species and larger containers are ideal for the larger fungi; this will reduce abrasion between specimens, contamination with spores of other species and loss of turgor. Very large bulky specimens e.g. boletes and russules can be placed in twists of waxed-paper or brown paper bags. Fragile and slender specimens are collected to advantage in tubes, preferably plastic, which can be kept upright in a container. If waxed-paper twists are used for such fungi a large can should be carried in order to stand the twists containing specimens upright, thus reducing jolting. Various sizes of boxes, tubes and packets can be arranged neatly in a market basket; it is more convenient to use such a basket than a plant vasculum for the specimens can be kept in a particular order and so retained in the same position, with a minimum of jogging throughout the collecting period.

Dig up the specimen complete or remove from the substrate along with a little of the latter; do not pull up or off with the fingers, in fact try to reduce the number of times the specimen has to be handled before it is examined in the laboratory. Collect whole specimens, do not pull the cap from the stem. It is always desirable to collect specimens in their peak of condition because decay, even of the freshest material, is often very rapid once the specimens have been brought indoors.

b) Field Notes

It is particularly important in the study of fungi to note the date of collecting, kind of substratum, and the host on which or under which the specimen is growing. When in doubt over the identity of the host or substratum bring back ample material for later identification by an expert. Note any color changes of the fruit-body which are observable in the field with the naked eye, and the odor if this is distinct (try to relate this latter character to some household commodity). Taste will be a useful character but should only be assessed when the student is familiar with his toadstool groups and genera. Ecological notes are very useful e.g. frequency of rain in the day before the fungus was collected, degree of shading, exposure, plant community, soil type, etc.

c) Preservation

Fleshy fungi should be dried fairly rapidly to discourage putrefaction; this also helps retain much of their form and color as possible. Ventilation is essential whilst the drying is being carried out; dry out over radiators or in an air-oven at medium temperature and with the door open. Delicate specimens can be dried by placing on the surface of fresh silica gel or simply placing them on a sunny window-sill. Robust specimens, like boletes, can be sliced to assist drying by either the silica gel method or an air-oven technique. Once dry the fungi are fairly brittle so great care must be taken when handling them any further. Specimens can be transported by placing them in twists of waxed-paper and packing them fairly tightly in cardboard boxes. When storing these twists containing specimens are best accompanied with a liberal sprinkling of paradichlorobenzine or naphtha to discourage beetle attack.

Bracket fungi must be dried for much longer periods than the more fleshy specimens because although they appear dry from the outside they may still retain within them considerable amounts of moisture; beetle larvae may still be active within the tissues. It is also wise to keep woody fungi quite separate from the other dried material when in storage for beetles are known to be active for many years within certain fruit-bodies; fumigation is often necessary at regular intervals.

Small fungi such as cup-fungi and their allies, including lichens, should be allowed to dry out at room temperature, if possible on a sunny window-sill, whereas plants on which rusts, smuts, and shot-hole fungi are observed may be treated as if they were flowering-plant specimens. It must be noted here that if fungi are attached to wood then insect larvae may still be present in the substratum; such material should be treated in the same way as woody fungi.

Note: Collecting and Caring of Botanical Specimens, D.B.O. Saville Publication No. 1113 Canada Dept. of Agriculture.

IDENTIFICATION

One of the most fundamental points to accept as a field mycologist is that a name is really of secondary importance. It is far, far better to know, in all its facets, the fungus one has collected, so that one can recognize it again in any of its variations, than to try and attach a name to it. If an undetermined specimen is carefully sketched and/or painted, accurately described and material cautiously dried and kept, then all the information possible is available for the future when the experience gained over a period of years may allow the collection to be identified; failing this an expert is sure to be able to assist, and one is able to offer the right information to such an expert when an occasion arises.

Careful, accurate observations and reporting is far more important in mycology than perhaps in other branches of botany for colors, form, etc., are soon lost on drying and mycologists have accumulated less information about their species than the flowering plant taxonomist has in a comparative group of angiosperms. Use a hand-lens in the field to detect small irregularities e.g. presence of hairs, wrinkles, etc. Fries, the father of mycology, did not use a microscope but the essence of his classification has stood the test of time (over one hundred years) even with the introduction of microscopic characters. Although microscopes have been used to study fungi for several generations, it is only recently that the results from their use have allowed a rather different approach to classification.

Once in the laboratory observe the specimen carefully under the low power of the microscope and note any salient features. Place the cap (pileus) gills-down on a glass-slide in a shallow container and leave for an hour or so; after this period a faint trace of mature basidiospores will have formed. For the color of the spore-mass a

deposit obtained overnight on a slide is required. The spores should then be scraped into a small pile with a coverslip and the latter be placed on the top of the pile so formed; only then can the deposit be compared with a standard color-chart.

MICROSCOPIC CHARACTERS

Mycelium an aggregation of hyphal strands (hyphae – singular. hypha – the unit of growth of a fungus).

Mycelial systems may or may not be complex, thus in yeasts the mycelium is reduced in form and divides by what is known as budding.

Mycelial systems may give rise to:

a) Oidia, a term applied to (1) arthrospores and (11) spermatia of heterothallic Hymenomycetes.
b) Chlamydospores – thick-walled, non-deciduous, intercalary or terminal asexual spores.
c) Stroma – a mass of vegetative hyphae in or on which spores or spore-bearing bodies are formed.
d) Sclerotia – firm masses of hyphae with or without addition of soil or host tissues; normally having no spores on it or in it.
e) Rhizomorphs – a thread or cord-like structures composed of intertwined and anastomosing hyphae, e.g. **Armillaria mellea.**
f) Rhizoids – root-like structures, e.g. **Rhizopus.**
g) Pseudorhizae – rooting portions of certain fruit-bodies, e.g. **Oudemansiella radicata**

Specialized hyphal units such as appressoria and haustoria for invading plant cells are found in certain parasitic fungi.

Clamp-connections:

When present they are said to characterize basidiomycetous fungi although they are absent from many otherwise typical Basidiomycetes; clamp-connection-like structures are found at the base of asci in several Ascomycetes and in certain parts of the fruit-body of truffles. When clamp-connections are found on vegetative hyphae it indicates a member of the Basidiomycetes.

Hyphal analysis

The flesh of most mushrooms and toadstools is composed of filamentous hyphae which in some places may become swollen or not but always giving a uniform tissue, excepting one group, the Russulaceae. In the genera **Russula** and **Lactarius** the flesh is composed of filamentous hyphae surrounding 'packets' of spherical cells (sphaerocysts); this produces the distinctly brittle flesh characteristics of this group of fungi. In the Russulaceae the flesh is said to be heteromerous and the other agarics are homoiomerous.

Hyphal analysis of polpores is a technique introduced by E. J. H. Corner and has been since taken up by several authorities: three main types of hyphae are to be found in woody fungi (1) generative hyphae, (2) skeletal hyphae, and (3) binding hyphae.

A fungus possessing only the first type, e.g. **Polyporus adustus** is called monomitic. A species containing types 1 & 2 is called dimitic, e.g. **Fomes - annosus.** A species containing all three types of hyphae types is called trimitic, e.g. **Polystictus versicolor.**

cf. structure of Discomycetes i.e. texturs globosa, textura prismatica, textura angularis, textura intricata; see R. Korf, A Monograph of the Arachniopezizeae, Lloydia 14: 129 – 180.

Spores

The term spore is a general name applied to the reproductive propagules of cryptogams, most commonly single celled, but not infrequently multi-celled. A diaspore is any unit of dissemination and may be a spore, fragment of mycelium or a sclerotium.

ASCOSPORE – a spore produced in an ascus.

BASIDIOSPORE – a spore produced on a basidium.

BALLISTOSPORE – any spore which is forcibly ejected after the formation of a droplet.

GASTROSPORE – a spore which develops within the tissue of certain woody fungi.

CONIDIUM or Conidiospore – general term for any asexual spore except intercalary thick-walled cells (chlamydospore and sporangiospores – see below). Conidium is a term applied to a spore of the Fungi Imperfecti.

Various systems of spore-terminology have been suggested for the Fungi Imperfecti depending on (a) their ecology i.e. dry or slimy spore-mass; Xero- and Gloio – (b) number of constituent cells; Amero –, Didymo –, Phragmo –, etc. (c) the way in which they are formed and/or borne; Phialo –, Blasto –, Arthro –, etc. (d) their shape; Helico –, Gonio –, Stauro –, etc. (e) color; Hyalo – and Phaeo – and (f) their relative size; Macro – and Micro –, when two types of spore are produced by the same fungus.

For the Phycomycetes the following spore-terminology is used:

SPORANGIOSPORE – an asexual spore produced in a sporangium, e.g. **Mucor.**

ZOOSPORANGIOSPORE – a motile sporangiospore.

APLANOSPORE – a non-motile sporangiospore.

ZOOSPORE – a motile spore or gamete.

ZYGOSPORE – a resting spore resulting from conjugation, e.g. **Mucor.** cf. the alga **Spirogyra.**

OOSPORE – a resting spore resulting from fertilization of an egg-cell, e.g. **Saprolegnia.** cf. the alga **Vaucheria.**

Specialized spore-terminology:

An ascospore may be more than one-celled and then may fragment; each separate section is then termed a part-spore. e.g. **Claviceps** Ergot of Rye.

Many rusts have a series of different types of spore in their life-history; pycno –, aecidio –, teleuto –, and uredospores. Some species of rust dispense with all but one spore type.

The basidiospores and basidia in the smuts have lost their true function; indeed some authorities do not believe they are true basidia.

CHARACTERS OF SPORE AND BASIDIA To look for in fleshy fungi:

SPORE

a) number and complexity of walls
b) position on the basidium
c) pigmentation
d) presence or absence of germ-pore
e) prominence of apiculus
f) surface markings
g) reaction with Melzer's reagent, i.e. amyloid (bluish, indigo, or purplish black), dextrinoid (purplish brown or rich red brown) and non-amyloid (no reaction – golden).

BASIDIA

a) whether of one or more sizes
b) whether borne on the fruit-body surface
c) 1, 2, or 4-spored
d) inaequihymeniferous versus aequihymeniferous gills

CYSTIDIA

Cystidia are sterile, more or less differentiated cells found on and in the fruit-body. Their classification is based on (a) position, (b) structure, and (c) function.

(a) Position

(1) dermatocystidia i.e. cystidia on the outside of the fruit-body pileo – on the cap (pileus) and caulo – on the stem (stipe).
(2) pleurocystidia – those on the gill face.
(3) cheilocystidia – those on the gill margin.

If the cheilocystidia and the pleurocystidia are alike then the gill is said to be subheteromorphous. If the cheilocystidia and the pleurocystidia are unlike then the gill is heteromorphous. If only cheilocystidia are present then the gill is pseudoheteromorphous. If the gills lack distinctive cystidia then they are homomorphus.

(b) Structure

(1) chrysocystidia – those with inclusions staining yellow in aqueous solutions of ammonia and deep blue in cotton blue in lactophenol.

(2) lamprocystidia – thick walled cystidia often called metuloids. e.g. **Pluteus** spp. **Inocybe** spp.

(3) leptocystidia – thin-walled cystidia.

Function

(1) brachycystidia – spacing cells, e.g. **Coprinus** spp.
(2) gloeocystidia – those containing oily material
(3) oleocystidia – those encrusted with resinous material
(4) macrocystidia – those which connect up with the vascular and lacticiferous system; usually discolor with aldehyde reagents, e.g. **Russula** spp. and often called pseudocystidia.

Note also Acanthophyses (– hyphidia)

(a) Cellules en brosse of French authors.
broom-cells (from their resemblance to brushes).
(b) Coscinoids cells containing sieve-like perforated plates.
(c) Hairs – hair-shaped cells which cannot be related to their types of cystidia.
(d) Cystidoles – aborted basidia or sterile often papillate basidia arising from the hymenial layer.
(e) Basidioles – basidia in which nuclear division is taking place. (often incorrectly applied to spacing cells under the names pseudoparaphyses or paraphysis).

Techniques for observing macro – and micro – structures are illustrated and dealt with in greater depth in Part II.

USE OF TEXTS AND KEYS

Texts:

Some texts are designed to cover the full range of fungi, whilst others relate certain groups one to the other. The latter may differ in their coverage, e.g. order, family, genus, or section of a genus. These are usually termed monographs. When approaching identification one should first locate the genus of the specimen in the general text book, then seek the species by keying it down and finally confirm your findings by reading the descriptions and looking at the colored plates in the text or searching the bibliography for a monograph on the group.

Keys:

Naturalness is often sacrificed in a key for convenience. A key is designed primarily for ease and certainty of identification and not to reflect evolution, although there is no reason why a key should not do so! If subgenera and sections however, are fairly natural and clear cut there is no reason why they should not be separated out as groups in the key. **A key does not intend to give phylogenetic associations.** Quanitative characters are better than qualitative one but mycologists have so few characters at their disposal; measurements of spores, basidia, etc., are frequently resorted to.

In mycology, unless the character is very decisive and easily observable single-character keys are difficult to use. Because of the ease with which otherwise obvious characters may be lost, e.g. color when young, usually two or more characters are given to assist in deciding between the two alternatives offered in the key (dichotomous). Unfortunately some keys have three alternatives (trichotomy) and confuse the beginner particularly when the keys run to

several pages. Always take great care when first using the key to note its particular format, for different types of keys exist in the literature.

is it (?)	1.....2	or	1.....2	or	1.....2	or	1.....2
	3		x.....3		1.....3		1*.....3
is it indented (?)	1.....2	or	bracketed without moves indicated (?)		1.....2	or	bracketed with moves indicated (?)
	1.....5				-....3		-.....6
	2....3						
	2....4				2....x		2(1) ...3
	etc.				-....x		•
							5
					3.....4		
					-.....x		3(2) 4
					4.....		-.....x
					etc.		etc.

is it a synoptic key (?)

A

1

a.....

b.....

c.....

2 a.....

b..... a.....

b.....

c.....

B

C

D

1

etc.

In all these cases completely contrasting clauses are advisable and necessary but are not always found in texts, e.g. Kuhner & Romagnesi under the genus **Omphalina.** Care must be taken because the paucity in the number of usable characters in the fungi often makes it necessary for the same species to appear more than once in a single key, this overcomes variability; it can still however mean that the species is autonomous.

In bracketed keys the move may be placed in parenthesis after a new couplet, for easy reference. This allows a back check to be made on any move.

An example of a key in which the number of signs for opening couplets becomes absurd is found in the ingenious "Nouvelle Flore des Champignons de France" by Constantin & Dufour.

Suggested references for the beginner:

European:

M. Lange & F. B. Hora, Collins Guide to Mushrooms & Toadstools, London, 1963, $5.95

E. M. Wakefield & R. W. G. Dennis, Common British Fungi, 1950 out of print, used copies sometimes available.

A. Pilat & O. Usak, Mushrooms, Spring Books, London, 1954, $19.25

_____, Mushrooms and Other Fungi, Nevill, London, 1962, $15.95.

American:

A. H. Smith, Mushroom Hunters Field Guide, Revised Edition, 1963, Ann Arbor, Michigan, $6.95.

L. R. Hesler, Mushrooms of the Great Smokies, Un. of Tennessee, 1960.

J. Walton Groves, Edible & Poisonous Mushrooms of Canada, $7.75.

Rene Pomerleau, Mushrooms of Eastern Canada and the United States, $7.50.

G. F. S. Atkinson, Mushrooms, Studies on American Fungi, New York, 1903, reprinted 1961, $15.00.

Outlines of Edible & Poisonous Mushrooms of Wisconsin, F. W. Hainer, $2.50.

L. C. C. Krieger, The Mushroom Handbook, 1935, Second Edition 1967 with appendix by R. L. Shaffer, $3.50.

Advanced Students:

C. H. Kauffman, Agaricaceae of Michigan, U. S. Geol. Survey, Lansing 1918, now in the Second Edition.

M. Moser, Kleine Kryptogamenflora von Mittleuropa Band II, Stuttgart Second Edition, 1955 (in German). Third Edition, Stuttgart 1967 (in French).

R. Kuhner & H. Romagnesi, Flore analytique des Champignons superieurs, Paris, 1953.

D. M. Henderson, P. D. Orton, & R. Watling, British Fungus Flora: Agarics & Boleti, Edinburgh 1969, a publication coming out in parts covering all the agaric families; full descriptions, etc. Published by Her Majesty's Stationery Office, Edinburgh.

R. Singer, Agaricales in Modern Taxonomy, Second Edition, Weinheim 1962, $30.00.

R. W. G. Dennis, F. B. Hora, & P. D. Orton, New Check List of Agarics & Boleti, Supplement to Vol. 43, 1960, and associated articles, supersedes Revised List of Agarics and Boleti, 1948 by Pearson and Dennis. Obtainable from the British Mycological Society, $2.50.

R. L. Shaffer, Key to genera of Higher Fungi, Univ. of Michigan, $3.00.

A selection of monographic works of North American Agaricales:

Boletaceae

The Boletaceae of North Carolina, W. C. Coker & A. H. Beers, Univ. of North Carolina Press, 1943, $9.50.

The Boletoideae of Florida, R. Singer, in the American Midland Naturalist and Farlowia.

A Contribution toward a Monograph of North American Suillus, A. H. Smith & H. D. Thiers, Ann Arbor, 1964.

Cortinariaceae

North American Species of **Crepidotus**, L. R. Hesler & A. H. Smith, Hafner New York, 1969, $12.50.

North American Species of **Gymnopilus**, L. R. Hesler, Mycologia Memoir No. 3; obtainable through the New York Botanical Garden and the Mycological Society of America.

North American Species of **Pholiota**, A. H. Smith & L. R. Hesler, Hafner, New York, 1969.

Hygrophoraceae

Hygrophorus of North America, L. R. Hesler & A. H. Smith, University of Tennessee Press.

A Monograph on the Genus **Galerina** Earle, R. Singer & A. H. Smith, Hafner, New York, 1964, $23.50.

Lepiotaceae

The Genus **Lepiota** in the United States, C. H. Kauffman, papers Michigan Academy of Science, 1924.

Rhodophyllaceae

Entoloma of South Eastern North America, L. R. Hesler, 1967, $20.00.

Russulaceae

Various groups of **Lactarius**, see L. R. Hesler & A. H. Smith in Lloydia.

Strophariaceae

A. H. Smith – Mycologia 43.

A. H. Smith & R. Singer – Mycologia 50.

Tricholomataceae

North American Species of **Mycena**, A. H. Smith, Univ. of Michigan.

Aphyllophorales & Gasteromycetes

The Polyporaceae of the United States, Alaska, and Canada, L. O. Overholts, $20.00.

Polyporaceae of North America, The genus **Poria** (1966, $2.25) and The genus **Fomes** (1957, $1.50), J. L. Lowe, Syracuse, New York.

Stipitate Hydnums of Eastern United States, W. C. Coker & A. H. Beers, North Carolina 1951, $16.00.

Thelephoraceae of North America, E. A. Burtt, 1926, $22.50.

Several popular foreign books are available, some with excellent illustrations:

a) Anderson, Kylir & Nannfeldt, Svenska Vaxter Kryptogamer Nordisk Rotograw, Stockholm, 1953.

b) Michael Hennig, Handbuch fur Pilzfreunde, Jena 1958 (3 parts).

c) H. Romagnesi, Petiti Atlas des Champignons, Bordas, 1962.

d) R. Heim, Les Champignons d'Europe, Paris, 1957.

e) H. Kleijn, Mushrooms and other Fungi, Oldborne Press, London, 1962, colored photos with texts, $11.95.

f) F. Muller, Wild Mushrooms, Zeitlmayr, London, 1968.

g) H. Haas, The Young Specialist looks at Fungi, Burke, London, 1969.

h) E. & H. Hvass, Mushrooms and Toadstools in Colour, $3.75.

i) J. Ramsbottom, Mushrooms and Toadstools, $7.00 (a general account)

j) C. M. Christensen, Molds and Man, $5.50.

k) W. P. K. Findlay, Wayside and Woodland Fungi, London, 1967, $12.95.

A useful guide to the literature for the identification of British Fungi is included in the Bulletin of the British Mycological Society, Vol. III (1) March 1969, obtainable from the British Society. It includes many references valuable to anyone working with temperate species of fungi.

Note: Physiological aspects of fungi are dealt with in:

Physiology of Fungi, L. Hawker, Univ. of London Press, 1950.

The Fungi, Vol. II, F. A. Wolf, F. W. Wolf, J. Willey, 1949.

See also:

a) Advance of the Fungi, E. C. Lange, 1940, $4.25 (a popular account on Plant Diseases)

b) Fungal Genetics, J. R. S. Fincham & P. Day, Blackwell, $9.95.

c) Mycorrhiza, J. Harley, Biology of Mycorrhiza.

d) Biology of Fungi, C. T. Ingold, Hutchinson Educational Series, 1961, $3.00.

e) Dispersal in Fungi, C. T. Ingold, Oxford University Press, 1953.

f) Soil Fungi & Soil Fertility, S. D. Garrett, Oxford, 1963.

INSTITUTES:

Where material will be checked and expert opinions given.

a) Commonwealth Mycological Institute, Ferry Lane, Kew: micro-fungi.

b) Royal Botanic Gardens, Kew, Richmond: cup fungi and relatives, Dr. R. W. G. Dennis. Aphyllophorales, Dr. D. Reid and Gasteromycetes, Dr. D. Dring.

c) Royal Botanic Garden, Edinburgh: Scottish mycological flora and its ecology, D. M. Henderson: Rusts and smuts, parasitic fungi. Dr. R. Watling: Agarics & Boletes and experimental techniques applied to agarics.

SOCIETIES

It is always advantageous to join a society in order to meet other amateurs, beginners, and the professionals. Experts on particular groups in these organizations will often assist in identification. (If you are not now a member of NAMA, see the introduction of this journal).

a) Mycological Society of America (MSA) publishes a news-letter and a journal, holds an annual foray. Professional.

Dr. R. L. Shaffer, Secretary – Treasurer
University Herbarium
University of Michigan
Ann Arbor, Michigan

b) North American Mycological Association (NAMA) publishes a newsletter and a journal, holds an annual foray. Amateur.
Mr. Neil Waterbury, Secretary
3 Ginger Hill Lane
Toledo, Ohio

c) British Mycological Society publishes the Transactions and a bulletin. Holds lecture meetings and Spring and Autumn forays.
Secretary, R. S. F. Macer
Plant Breeding Station, Rothwell
W. Castor, Lincolnshire, England

d) French Mycological Society, publishes the Bulletin and holds several forays in different parts of France annually.

e) Boston Mycological Club (BMC)
Farlow Herbarium, 20 Divinity Ave.
Cambridge, Massachusetts 02138

f) New York Mycological Society (NYMS)
Mrs. J. P. Grebanier, Secretary
1866 E. 4th Street
Brooklyn, New York 11223

g) Spokane Mushroom Club (SMC)
Mrs. Elton King, Secretary
N. 1812 Stevens Street
Spokane, Washington 99205

h) Mycological Society of San Francisco (MSSF)
Randall Junior Museum
Roosevelt Way & 16th Street
San Francisco, California 94114

i) **Additional Societies:**
Colorado Mycological Society
909 York Street
Denver, Colorado 80206

Tri-Cities Mycological Society
Mrs. Berle Bezzio, Secretary
614 Cottonwood Drive
Richland, Washington 99352

CULTURING FUNGI

The isolation and cultivation of fungi in pure culture constitutes an essential procedure in the study of the structure, development, physiology, genetics, etc. of these organisms.

Many different techniques have been developed for isolating and growing fungi in pure culture. The choice of method depends on the fungus under observation and the type of study being conducted.

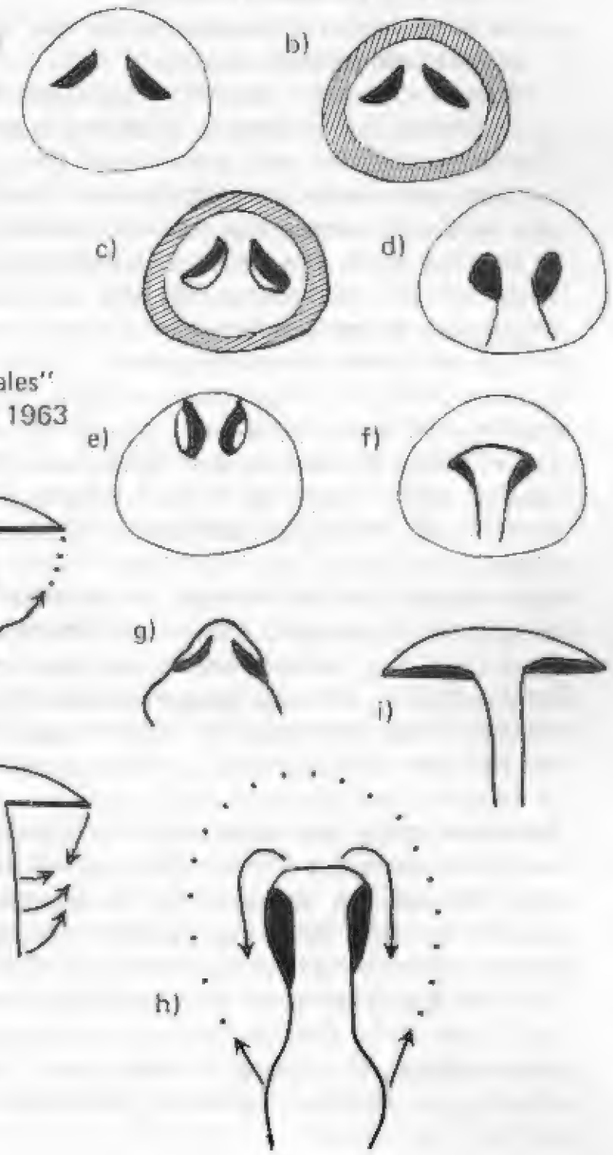
It is impossible herein to describe cultural techniques and readers are referred to small books as "Class Work with Fungi" by Dade & Gunnell, 1966, issued by The Commonwealth Mycological Institute, Kew. Price $2.25.

DEVELOPMENT

Angiocarpic (hidden); Gynocarpic (exposed).

a) paravelangiocarpic
b) monovelangiocarpic
c) bivelangiocarpic
d) pileoangiocarpic
e) stipitoangiocarpic
f) bulboangiocarpic
g) gynoangiocarpic
h) metavelangiocarpic
i) strictly gynocarpic
j) mixed development

see: A. F. M. Reijnders
"Development des Agaricales"
Junk, Hague, Netherlands 1963



ECOLOGY

Frequently macro and microscopic species of fungi have very characteristic habitats. Various terms have been coined to cover some of their habitats; these often appear in the species epithet, e.g. –cola meaning 'I live' as in fimicola, dung inhabiting and lignicola – wood inhabiting. See also –phila meaning 'I love' as in coprophila – dung loving.

praticolous, i.e. grassland species, e.g. **Galerina praticola.**

silvicolous i.e. woodland species, e.g. **Agaricus silvatica & A. silviocola.**

muscicolous i.e. growing in moss, e.g. **Leptoglossum muscigenum.**

When particular species of moss are involved the moss genus may be incorporated into the epithet, e.g. **Omphalina sphagnicola** (Sphagnum), **Galerina hypnoium** (Hypnum), etc.

coprophilous, i.e. growing on dung e.g. **Deconica coprophila;** or fimicolous, e. g. **Panaeolus fimicola.**

carbonicolous, i.e. growing on the site of old fires, e.g. **Pholiota carbonaria, Hebeloma anthracophila.**

growing in dunes – 'dunensis', e.g. **Conocybe dunensis.**

lignicolous, i.e. growing on wood, e.g. Boletue lignicola.

Lignicolous species may grow either (a) on any woody debris or may be confined to a particular type of wood, e.g. (b) hardwood or (c) only on wood of a particular species, e.g. oak –quercicola. They may also differ in the part of the tree which they colonize: (a) on all types of woody debris, (b) only on twigs, (c) only on branches, (d) only on trunks, (e) only on shanks, (f) only on stumps, or any combination of two or more. (see Cartwright & Findlay, "Decay of Timber and its Prevention").

Fungi growing on substrates other than wood may have a preference also, e.g. only on leaves or leaves of a particular plant, e.g. **Marasmius hudsonii** on Holly leaves, **M. buxi** on Box leaves, and **M. androsceus** on pine needles or heather leaves. Some are only on fruits, e.g. **Flammulaster carpophila** on Beech mast, **Strobilurus conigena** on **Pinus** cones, and **S. tenacella** on **Picea** cones.

Some agarics simply live in or on leaf litter – humicolous, these are saprophytes. Some however, prefer base rich humus, i.e. brown earth conditions (mull soils), e.g. **Lepista nuda,** whilst others prefer acidic soils, i.e. raw humus (mor soil) e.g. **Mycena sanguinolenta.** The associated plant cover often influences the magnitude of fruitification of the fungi present in an area; this has been demonstrated by removing heather from areas of woodland and so enhancing the production of agarics.

Two other major ecological groups of agarics can be defined, those parasitic on higher plants, e.g. Honey fungus, **Armillaria mellea, Oudemansiella** spp. on trees (**O. radicata** on roots and **O. mucida** on standing trees) and those parasitic on other fungi, e.g. **Nyctalis** on **Russula** spp., and **Lactarius** spp., and **Boletus parasiticus** attacking Earth-balls (**Scleroderma** spp.). A less definable group of agarics composes those which are termed mycorrhizal fungi. Particularly those which have an underground symbiotic relationship with tree-roots (ectotrophic). This group includes many members of our more obvious genera, e.g. **Russula, Lactarius, Cortinarius, Boletus,** and **Amanita.** The

habit of these mycorrhizal fungi is again sometimes reflected in the epithet, e.g. **Boletus pinicola** – under pines. There are a few fungi with very constant habit requirements but we know little about the factors involved, e.g. **Naucoria escharoides** and related species, and **Paxillus filamentosus** are confined to the water-logged soil about alder trees.

Alpine communities in many ways resemble those found at lower altitudes although the higher plants in the community are rather more specialized; thus there are praticolous species and silvicolous species growing amongst **Salix** spp., **Betula nana,** etc., e.g. **Amanita nivalis** (white from the place where it lives, near the snow line, not the color). Also found in these high altitudes are fungi which grow on bare peat, e.g. **Omphalina luteo-lilacina** and **O. luteovitellina,** apparently always associated with algal scums, or the lichens **Corsicium** and **Botrydina.**

Often a distinct succession of fungal colonists can be recognized if a single substrate is kept under constant observation; the coprophilous habitat is a good example. See M. J. Richardson and R. Watling, "Keys to Coprophilous Fungi", Bulletin of the British Mycological Society, obtainable from that society.

Fairy rings are the result of radial growth of many praticolous fungi, the presence of the fungus brings about changes in the vegetation both in its growth rate and in its species constitution.

Time of Appearance:

Many fungi typify a particular season, others are to be found whenever favorable weather conditions prevail. However, it is a fallacy to say that higher can only be found in the autumn; certainly the fungi are in greater numbers at this time of year and the more familiar larger species observable, but throughout the year successful collecting can be carried out. For instance in Spring there usually occurs a distinct flush of fruit-bodies; a dung heap in Spring can produce up to two dozen higher fungi.

Never-the-less certain species have been said to indicate the particular stage of the season. **Tricholomopsis platyphylla** is regarded as the indicator of the fungus season; **Hygrophorus hypothejus** on the other hand is called the "Herald of the Winter".

The four seasons frequently appear in the species epithet, e. g. **Psathyrella vernalis** (spring), **Boletus aestivalis** (summer), **Galerian autumnalis** (autumn). and **Clitocybe brumalis** (winter).

European Mapping Scheme:

This is a pilot scheme formulated to encourage mycologists throughout Europe to map 100 species of the higher fungi. The species chosen include some Ascomycetes, but by far the greatest number are Basidiomycetes. Certain species have been chosen because they show habitat preferences, some because they show a southerly or northerly distribution, others because they show continental, atlantic, cosmopolitan, or circumpolar distribution.

EVOLUTION

It is impossible in a short space such as this to discuss at any length ideas on evolution; never-the-less it is felt important enough to mention here at least something about the basic ideas and so stimulate an interest in the fungi over

and above those species which may be seen in the field. It also will indicate that mycology is not static, but an expanding world of knowledge. Various theories on the evolution of the fungi have been put forward, but the main ideas appear to be variations on those of three school of thought. Firstly that of Atkinson, a theory which can be mentioned and passed over rapidly, not because it is basically wrong but because it is simple in outline; here the fungi are considered to be a homogeneous group of organisms (monophyletic), the different developmental patterns exhibited being simply parallelisms to those found in the algae. The other two hypotheses agree that the fungi are heterogeneous (polyphyletic); the only ways in which the theories diverge is that the proposed origins are to be sought amongst rather different origins.

Phycomycetes: The presence or absence of cellulose in the cell wall and the position of the flagella on the zoospores are important points. Four types are to be noted:

1. Anterior flagellum lost	Chytridiomycetes
2. Posterior flagellum lost	Hyphochytridiomycetes
3. Both flagellae retained	Oomycetes & Plasmodiophoromycetes
4. No zoospores formed	Zygomycetes & Trichomycetes

Some authorities think the Zygomycotina and Oomycotina are closely related, the latter having given rise to the former; others think that the two groups are quite unrelated. There are amazing parallelisms between the filamentous yellow-green algae and some of the lower fungi and this appears to correlate in part with the presence of cellulose in the cell-wall. e.g. **Vaucheria: Saprolegnia.**

The parallelisms between the red algae and the antheridia/oogonial systems found in many Ascomycetes led Corner and Sachs to believe these two groups were closely related, probably with a common ancestor. Thus the true cup-fungi were connected to the red algae, with the "Laboulbeniomycetes" as an off-shoot very close to the separation of the two groups. The 'Discomycetes' gave rise to the 'Pyrenomycetes' by closing and hardening of the cup and from the latter by reduction at least some of the 'Plectomycetes' were thought to be developed. The second school of thought, however, would seek the origin of the 'Discomycetes' in the Zygomycotina through some of the 'Plectomycetes', e.g. **Aspergillus/Eurotium**-like fungi, and then derived the 'Pyrenomycetes' in much the same way, suggested by Sachs. In this hypothesis members of all groups would give rise by reduction to fungi which would be classified in the heterogeneous group, the 'Plectomycetes', e.g. Downy mildews, **Erysiphe** spp.

What is usually unamimously agreed is that the **Basidiomycotina** because of their similarities in wall-structure, cell-development, etc., with the **Ascomycotina** have in fact been through **Taphrina**-like fungi (and **Ascocorticium**) to the **Corticiaceae** (in its wildest sense) where the hymenium is flat or undulating but orientated in much the same way as the inner parts of the receptacle of a cup fungus. From the **'Corticium'** ancestor evolution into the fairy clubs, the jelly fungi, polypores, etc., can be easily appreciated. The summit of such phylogenetic mapping in most theories would lead to a fungus of an agaric-like structure. Much controversy, however, rages as to where the

Gastromycetes fit into this pattern and where the rusts and smuts might be placed. Gaumann would evolve the former from the **'Corticium'** stock to finally give several groups where the palisade of reproductive tissue, although borne in a definite fruit-body, often in every way as complex as in the agaric or polypore, is completely enveloped. Singer on the other hand would not accept a parallel development in the two groups but would evolve the agarics from the gastromycetes.

There is little doubt that there is sufficient information available to show that several patterns are taking place and have taken place; some information supports the view that some agarics are giving rise to gastromycetous fungi by non-expansion and sealing off of the lower part of the pileus.

The rusts and smuts pose a much tougher problem. Bessey would develop them in parellel to our primitive **'Corticium'** ancestor from the Hemiaascomycetes from which point they developed similar structures to the jelly fungi; the last group would be considered a branch of the **'Corticium'** line. Gaumann on the other hand developes the same groups from the primitive **'Corticium'** along with all the other fungi with a septate basidia. What many mycologists forget is that some of the 'missing-links' are either present and not recognized, or lost, even in the fossil history.

Fossil fungi

Few contributions to our knowledge of fossil fungi have been made by mycologists; the field has been left to geologists but unfortunately frequently their knowledge of fungi, although exceeding the mycologist's acquaintance with geology, is still very inadequate.

From Devonian onwards there were parasitic and saprophytic fungi, however, most records are from the Tertiary and Quaternary. (See F. A. Wolf and F. W. Wolf, 1949).

The following facts may be listed:

Myxomycotina — 1. 'Phycomycetes' not more than 50.

Ascomycotina — over 100 species of Sphaerites have been described and over 50 species of **Rhytismites** and **Phacidites.**

Basidiomycotina — Shelf fungi **Polyporus vaporarius** f. **succinea** from amber and **Polypotites brownii** (Lower Cretaceous of Montana). **Polyporites bowmanii** may be a fish scale. **Rhizomorpha sigillariae** may be an insect burrow.
Polyporites filiatus from the Tertiary and **Pseudopolyporus carbonicus** from the Carboniferous.
Several rusts and smuts have been recorded:
Clavaria turbinata from the Quaternary.
Hydnites argillae: Lenzitites gastaldii, the Tertiary.
Agaricites wardianus: Geasterites florissantensis, Miocene.

Deuteromycotina — a rather wide range of fossilized Fungi Imperfecti, many from amber, have been discovered.
It should be noted that mycorrhizal relationships are known from the Devonian.

KEYS TO MAJOR GROUPS OF THE FUNGI

1. Mycelium lacking — 'Myzomycetes' = Myxomycota.
   (Slime fungi and related organisms, e.g. **Fuligo septica** — "Flowers of Tan"). Certain types of **Chytridiomycetes** where the vegetative thallus is a single cell may be keyed out here: c.f. budding cells of certain yeasts.
1. Mycelium present ..... 2, = **Eumycota.**
   2. Mycelium coenocytic and/or developing large resting spores either from the fusion of two hyphal protuberances (Zygospores), or by fusion of an egg-cell and one more antheridia (oospores) .....3 (Phycomycetes)
   2. Mycelium separate and never forming specialized egg-cells or fusion-cells ..... 5.
3. Reproduction by means of zygospores or by oospores .... 4.
3. Sexual reproduction lacking.... 'Fungi Imperfecti' — **Phycomycetes.**
   4. Reproduction by motile zoospores and/or by fertilization of egg-cells (oogamy) ..... 'Oomycetes' = **Mastigomycotina.**
   Contains three unrelated groups ... **Chytridiomycetes.**
   Hyphochytridiomycetes and **Oomycetes** (e.g. **Saprolegnia ferax** — disease of Salmon; **Phytophthora infestans** — potato blight)
   4. Reproduction by fusion of two hyphal protuberances or by spontaneous production of large thick-walled resting spores (zygogamy ..... 'Zygomycetes' = **Zygomycotina.** Contains two probably not closely related groups (e.g. Mucor mucedo — bread mold) **Zygomycetes,** and **Trichochomycetes** (mostly internal parasites of Arthropoda)
5. Spores formed on mycelium or in fruit-bodies connected to the mycelium 6
5. Spores never formed, hyphae fragmenting irregularly of forming sclerotoid bodies ..... **Deuteromycotina** see No. 8, 'Mycelia Sterilia' = **Agonomycetes.**
   6. Spores formed within special sacs produced by the fruit-body or borne borne externally on specialized cells of the fruit-body; usually in groups of two or four and multiples thereof and when external borne, apical to subapical 7
   6. Spores neither borne within a sac nor externally on a specialized cell in multiples of four 9
7. Spores (ascospores) borne within a sac (ascus) and usually eight in number (but if not usually in factors of eight, 16, 32, etc.); the ascus may rapidly disappear when the spores mature ... **Ascomycotina** ('Ascomycetes') split into several artifical groups ... **Hemiascomycetes** (e.g. **Saccharomycetes** — baker's Yeast), **Plectomycetes** (e.g. Erysiphe graminis — powdery mildew of grasses), **Pyrenomycetes** (e.g. **Xylaria hypoxylon** — candle-snuff fungus), **Discomycetes** — cup fungi (e.g. **Peziza** spp. — elf cups), **Laboulbeniomycetes** (parasites and epiphytes of beetles), and **Loculoascomycetes** (e.g. **Caprodiaceae** — sooty molds).
7. Spores borne on a specialized cell 8
   8. Spores (basidiospores) produced sexually and borne on a specialized structure (on the apex of a spine which surmounts and is part of a clavate or cylindrical cell (basidium), in groups of two or four, normally the latter, more rarely in eights, clamp-connections frequent on hyphae and/or at the base of the basidium ..... **Basidiomycotina**
   Split into three groups, two of which appear to be separated from each other on quite artificial grounds ... **Hemibasidiomycetes** (Rusts, smuts, and bunts) e.g. **Puccinia graminis** — rust of wheat; **Hymenomycetes** (Agaricales — toadstools and mushrooms = agarics); **Aphyllophorales** (Polyporales) — polypores, fairy clubs, etc.; **Tremellales** — jelly fungi and similar organisms; **Gastromycetes** (**Lycoperdales** — puffballs, **Sclerodermatales** — earth balls, **Nidulariales** — bird nest fungi, **Phallales** — stink horns, and **Hymenogastrales** — false truffles).
8. Spores (conidia) produced asexually, and borne in groups on variously shaped cells or on groups of cells (coindiophores), rarely on spines arising from the sporogenous cells, rarely in groups which are multiples of four and rarely if ever with clamp-connection-like structures on the hyphae.....**Deuteromycotina** 'Fungi Imperfecti' — fungi which lack a known sexual—cycle includes the asexual stages of many familiar **Ascomycetes.**
   Conidiophores borne in cup-shaped or flask-shaped fruit-bodies (**Coleomycetes:** stem and leaf fungi, e.g. **Ascochyta pisi** (pea spot) or Conidiophores in clusters or solitary and lacking specialized fruit-bodies (**Hyphomycetes,** e.g. **Botrytis cinera** — grey mold of vegetables.)
9. Reproduction zygogamous ..... see No. 4 **Zygomycotina**
9. Sexual reproduction absent; spores (conidia) borne in groups on or in variously shaped cells which are solitary, grouped, or enclosed in flask-shaped or cup-shaped fruit-bodies .... **Deuteromycotina**.....See No. 8 Included here are certain members of the 'Zygomycetes' closely related to the Mucoraceae although the sexual stages are rarely if ever seen.

The key below is designed to allow the majority of the boletes and agarics, likely to be met within the course of an amateur's collecting, to be accomodated with some satisfaction in the system of classification which is now widely accepted (in broad terms) by professional mycologists. The Key has been tested over many seasons in the British Isles by students and has proved satisfactory; it is on this that the one in the British Fungus Flora: Agarics & Boleti is based. It does not attempt to accomodate tropical fungi.

1. Stipe central 2
1. Fruit-bodies with excentric, lateral or rudimentary stipe 24
   2. (1) Fruit-body fleshy never resupinate; hymenium borne on the inside of short or long, but distinct, tubes or depressions or on anastomosing gills; trama bilateral 31
   2. Fruit-body fleshy or tough; hymenium distinctly lamellate (on gills) ..3

3. (2) Basidiospores ornamented with amyloid ridges and cap trama heteromerous.... **Russulaceae.**
3. Basidiospores smooth or ornamated and if with amyloid ridges and ornamentation then cap trama homoiomerous.....4
4. (3) Gill-trama bilateral 5

4. Gill-trama inverse, regular or irregular 9
5. (4) Spore-print cream, pink, or with a flush of green or grey....6
5. Spore-print darker in color, brown, black, etc., and spores distinctly colored under microscope.....8
6. (5) Gills, thick, waxy; basidia typically long, cylindrical often more than five times as long as the spores....**Hygophoraceae.**
6. Gills rarely thick or waxy, or if so then the spores ornamented with spines, basidia shorter 7
7. (6) Gills free or nearly so; veil often well developed and then leaving a ring and/or volva .....**Amanitaceae.**
7. Not as above ...See **Tricholomataceae.**
8. Spore-print almost black; gills decurrent .....**Gomphidiaceae.**
8. Spore-print brown with a flush of chocolate or olive...**Paxillaceae.**
9. (4) Dasidiospores angular or longitudinally ridged ...10
9. Basidiospores smooth or if ornamented never angular 11
10. (9) Basidiospores with longitudinal ridges, angular in transverse section only ..... **Tricholomataceae.**
10. Basidiospores irregularly angled, cubic, rhomboid, etc, angular in all optical sections..... **Rhodophyllaceae.**
11. (9) Spore-print pink, vinaceous, tawny, tan, buff, but never cream or white. 12
11. Spore-print either white, cream, or dark and then ferrugineous, russet, purple-brown, etc. 14

12. Spore-print pink; gill-trama inverse ....**Volvariaceae.**
12. Spore-print never pink or if flesh colored gill-trama never inverse 13
13. (12) Spore-print vinaceous, buff, etc., 'scalp' of pileus composed of ± isodiametric cells .....**Coprinaceae.**
13. Not as above .....**Tricholomataceae.**
14. (11) Spore-print white or cream perhaps flushed with lilac, green, or grey.....15
14. Spore-print dark ferrugineous, brown, chocolate, purple-brown, or black 17
15. (14) Gills free: veil well developed ± forming a ring... **Lepiotaceae.**
15. Gills adnexed, adnate, or decurrent; veil absent, rudimentary or if present soon lost....16
16. (15) Gills thick and waxy, fruit-body often brightly colored, basidia over five times as long as spores....**Hygrophoraceae.**
16. Gills neither thick nor waxy, basidia shorter than above ..... **Tricholomataceae.**

17. (14) Cap cuticle a palisade of inflated cells or only of inflated ± isodiametric cells, or less frequently covered by cells of similar shape from a veil 18
17. Cap cuticle composed of strictly filamentous cells or mixture of free, ellipsoid cells and filamentous cells 21
18. (17) Spore-print some shade of red-brown 19
18. Spore-print purplish brown, chocolate to black 20
19. (18) Spore-print rust to hazel brown ..... **Bolbitiaceae.**
19. Spore-print not so, more cinnamon or olivaceous brown ..... **Cortinariaceae.**
20. (18) Gills free to remote; veil well developed, usually leaving a ring .... **Agaricaceae.**
20. Gills attached to stipe or if free then veil absent or rudimentary .....**Coprinaceae.**
21. (17) Gills free: fruit-body not deliquescent, hymenium frequently inequihymeniferous 22
22. (21) Gills deliquescent ..... **Coprinaceae.**
22. Gills not deliquescent; hymenium dequiphymeniferous 23
23. (22) Basidiospores truncate and/or with a distinct pore at the apex, purplish brown in mass, purplish sepia to olive-yellow in KOH..... .....**Strophariaceae.**
23. Basidiospores neither truncate nor with a distinct pore at the apex, rust in mass, golden honey color in KOH ....**Cortinariaceae.**
24. (1) Spore-print distinctly colored 25
24. Spore-print white or pale but never darker than ivory.....29
25. (24) Spore-print pink 26
25. Spore-print brown to purple-brown, spores smooth to punctate never angular in optical section 27
26. (25) Basidiospores angular in all optical sections..**Rhodophyllaceae.**
26. Basidiospores angular in transverse section only..**Tricholomataceae.**
27. (25) Spore-print purplish brown.....**Strophariaceae.**
27. Spore-print snuff-brown, buff, rust to fulvous.....28
28. (27) Spore-print pale snuff-brown, buff or fawn.....**Cortinariaceae.**
28. Spore-print rust.....**Paxillaceae.**
29. (24) Fruit-body tough when dry and reviving on moistening; gills split or crisped along the edge.....**Schizophyllaceae.**
29. Fruit-body fleshy and not reviving or if woody the gills triangular or wedge shaped in cross-section, never crisped or split.....30
30. (29) Fruit-body tough; basidiospores cylindric, allantoid, to elongate ellipsoid, non-amyloid.....**Pleurotaceae.**
30. Fruit-body putrescent; spores ellipsoid to ovoid, amyloid or not ..... **Tricholomataceae.**
31. (2) Fruit-body with distinct, short or long, tubes.....**Boletaceae.**
31. Fruit-body lacking tubes 32
32. (31) Hymenium furrowed with the majority of basidia replaced by a powdery mass of chlamydospores; fruit-body parasitic on

Russulaceae .....**Tricholomataceae.**

32. Hymenium covering anastomising gills or depressions, or if furrowed then basidia normal and fruit-body saprophytic.....33

33. (32) Fruit-body growing on vegetable debris; cap small, less than 15mm .....**Tricholomataceae.**

33. Fruit-body terrestrial; cap greater than 15mm 34

34. (33) Spore pale white to cream and with hint of pink .....**Cantharellaceae.**

34. Spore-print rust color.....**Paxillaceae.**

The classical approach adopted by Massee, Peck, Worthington, Smith, Cooke, and Kauffman is now considered to be inadequate to relate genera of Agarics which are now considered to have strong natural affinities. It was during the period of Fries and later that of Massee, Peck, etc., that the majority of our most familiar toadstools were named. As the classification of the earlier persists in many text-books and in order to allow the amateur to inter-relate the old with the new the following table is added. It must also be noted that the earlier mycologists considered that the majority of the agarics were members of the large family **Agaricaceae.**

	WHITE	PINK	BROWN	PURPLE	BLACK
I. Fleshy; not leathery nor woody					
A. Ring or volva present	AMANITACEAE				
1. Ring & Volva present	Amanita	–	–	–	–
2. Only volva present	Amanitopsis*	Volvaria*	Acetabularia*	–	–
3. Only ring present	LEPIOTACEAE	Annularia*	–	Chitonia*	–
	Lepiota	–	–	Psalliota*	Anellaria*
4. Gills free					
Gills adnexed or slightly decurrent	TRICHOLOMATACEAE		CORTINARIACEAE	STROPHARIACEAE	
	Armillaria	–	Pholiota	Stropharia	–
B. Neither ring nor volva present					
5. Gills waxy	HYGROPHORACEAE				GOMPHIDIACEAE
	Hygrophorus	–	–	–	Gomphidius
6. Gills exuding a milky juice when broken	RUSSULACEAE				
	Lactarius	–	–	–	–
7. Stem excentric or wanting	PLEUROTACEAE	RHODOPHYLLACEAE	CORTINARIACEAE		
	Pleurotus	Claudopus	Crepidotus	–	–
8. Stem cartilaginous					
9. Gills decurrent	Omphalina	RHODOPHYLLACEAE	Tubaria	–	–
	–	Eccilia	–	–	–
Gills adnate or free	Collybia	RHODOPHYLLACEAE	Naucoria	Psilocybe	Panaeolus
	–	Leptonia	–	–	–
Gills sinuate	Mycena	RHODOPHYLLACEAE	Galerina	Psathyra	Psathyrella
	–	Nolanea	–	–	–
10. Stem fleshy					
11. gills free	Hiatula	VOLVARIACEAE	Pluteolus	Pilosace*	–
	–	Pluteus	–	–	–
Gills sinuate	Tricholoma	RHODOPHYLLACEAE	Hebeloma	Hypholoma	–
	–	Entoloma	–	–	–
Gills decurrent & fold-like	CANTHARELLACEAE				
	Cantharellus	–	–	–	–
Gills decurrent & thin	Clitocybe	TRICHOLOMATACEAE	Flammula	–	–
	–	Clitopilus	–	–	–

The * indicates genera no longer or rarely found in textbooks today and need some clarification.

					Gills decurrent & easily separable
					Gills adnate; on agarics Gills adnate and brittle; often brightly colored
					c. With arachnoid or Filamentous veil
					12. Veil forming ring on stem
					13. Veil adhering to cap cuticle
					ii. Membranous or fleshy membranous, fragile, rapidly putrescent
					14. autodigesting
					iii. Tough, coriaceous & woody
					15. Stem central
					16. Gills simple
					Gills branched
					17. Stem lateral or absent
					18. Gills anastomosing
					Gills simple, edge entire
					Gills simple, edge toothed
					Gills crisped & split longitudinally
					Gills crisped & obtuse
					TRICHOLOMATACEAE Paxillus-1
					Nyctalis
					RUSSULACEAE Russula
					POLYPORACEAE Lenzites
					Panus
					Lentinus
					Schizophyllum
					Trogia
		PAXILLACEAE Paxillus-2			
		Cortinarius			
		Inocybe			
		Bolbitius			
			Psathyrella		
			Coprinus		
					Marasmius Xerotus

Acetabularia is a confused concept. **Amanitopsis** is included in **Amanita. Chitonia** is the same as **Clarkeinda** — Agaricaceae. **Psalliota** is now **Agaricus** s. stricto. **Pilosace** is now included in **Agaricus. Hiatula** is the same as **Leucocoprinus. Psathyra** is included in **Psathyrella. Flammula** is in part placed in **Pholiota** and part in **Gymnopilus. Anellaria** refers to annulate species of **Panaeolus. Annularia** is a mixed concept. The white spored **Paxillus** are **Lepista** in the Tricholomataceae while the brown spored **Paxillus** are **Tapinia** in the Paxillaceae. Both genera are no longer used; **Paxillus** is retained for brown spored species. **Panus** and **Lentinus** are now split into two genera, each depending mainly on the reaction of the spore wall with Melzer's reagent. See Pleurotaceae, Tricholomataceae and Auriscalpiaceae.

The horizontal groupings which although interconnecting unrelated genera nevertheless do reflect some form of parallelisms in gill attachment, etc. This can be done by using the name of a constituent member of the series; thus such small, fragile fruit bodies with sinuate gills are termed mycenoid after **Mycena.** Genera in column 1 are usually used in such references: tricholonoid, pleurotoid, clitocyboid, collyboid.

GENERA of the APHYLLOPHORALES and AGARICALES

(G = Gasteromycetes)

a) Aphyllophorales

In the main modified from M. A. Donk, "A Conspectus of the Families of Aphyllophorales", Persoonia 3, 1964.

Auriscalpiaceae, Maas Geersteranus

Auriscalpium and Gloiodon; Lentinellus (placed in the British Check list of Agarics and Boleti in the Pleurotaceae).

Bankeraceae, Donk

Bankera and Phellodon

Bondarzewiaceae, Kol. & Pouzar

Bondarzewia and Amylaria

Cantharellaceae, J. Schroeter (as outlined in the British Check List, a rather mixed concept)

Cantharellus, Craterellus + 2

Clavariaceae, Chev.

1) Pteruloideae Pterula + 3

2) Clavarioideae, Clavaria, Pistillaria, Typhula, etc., after removal of those species with monomitic structure and non-inflated hyphae.

Clavulinaceae, Donk

Clavulina

Coniophoraceae, Ulbr.

Coniophora, Gyrodontium, Gyrophora, Serpula, etc.

Corticiaceae, Herter — a rather artificial assemblage of genera (and species)

Sistotrema, Aleurodiscus, Vuilleminia, Odontia, Mucronella, etc.

Peniophora — mixed group of species. Corticium and residual genera, Petersen suggests the inclusion of Cristella, Ramariopsis, and Tulasnella (formerly placed in the Tulasnellales: Tulasnellaceae).

Echinodontaceae, Donk

Echinodontium

Fistulinaceae, Lotsy
Fistulina and pseudofistulina
Ganodermataceae
Ganoderma, Amauroderma + 2.
Gomphaceae, Donk
Ramaricium, Kavinia, Ramaria, Lentaria, and Beenakia.
Gomphus + 2 and possibly Clavariadelphus (Gomphus in the British Check List has been classified in the Cantharellaceae).
Lachnocladiaceae, Reid
Lachnocladium, Dichopleuropus, Vararia, and Asterostroma
Hericiaceae, Donk
Hericium, Creolophus, Clavicorna, Laxitextum, Dentipellis & Steecherinum
Hydnaceae, Chev. a problematic assemblage of possibly unrelated genera.
Hydnum + 5 (might have to include Steccherinum now in Hericiaceae.
Hymenochaetaceae, Donk
1) As sterostromatoideae: see Reid's Lachnocladiaceae
2) Hymenochaetoideae: Asterodon, Clavariachaete, Hymenochaete. Hydrochaete and Phellinus + 10.
Podoscyphaceae, Reid
Podoscypha, Cymatoderma, and Cotylidia.
Polyporaceae, Corda, probably a very artificail assemblage of unrelated genera.
(Polyporoideae) many of our common polypores: Polyporus, Pycnoporus, Piptoporus, Trametes, Fomitopsis, Oxyporus, Poria, etc.
(Pleurotoideae) see Pleurotaceae below — Lentodium (G)
Punctulariaceae, Donk
Punctularia
Schizophyllaceae
Schizophyllum (placed in the Pleurotaceae in the British Check List). Plicaturiopsis, Stromatoscypha, and Henningsomyces — may have to be eliminated from the family. Plicaturiopsis (as Plicatura) has been referred by the British Check List to the Cantharellaceae.
Sparassidaceae, Herter
Sparassis
Stereaceae, Pilat
Stereum and segregates, e.g. Amylostereum
Chondrostereum + 2, Mycobonia + 1, for Cotylidia see Reid's Podoscyphaceae.
Thelephoraceae, Chev. (Boletopsidaceae)
Tomentella, Caldisiella, Thelephora, and Scytinopogon.
Hydnellum, Sarcodon, Boletopsis, Polyzellus, and Lenzitopsis.

A summary of the hymenial pattern, i.e. whether poroid, agaricoid, etc., over the family of the Aphyllophorales is illustrated by the following table; Donk, 1964 is followed closely. In these families examples are given to illustrate the diversity of hymenium within that family.

Hymenium configuration	on gills	club-shaped fruit-body	smooth to rugulose surface	on teeth	in tubes	on poorly developed veins
Families:						
Auriscalpiaceae	Lentinellus			Auriscalpium		
Bankeraceae				X		
Bondarzewiaceae		X	?		X	
Cantharellaceae			X			X
Clavariaceae		X	?			
Clavulinaceae		X				
Coniophoraceae	?		X	X	X	X
Corticiaceae		?	X	X	X	X
Echinodintiaceae				X		
Fistulinaceae					X	
Gandodermataceae					X	
Gomphaceae		Ramaria	Ramaricium	Beenakia		Gomphus
Lachnocladiaceae		X	X			
Hericiaceae		X	X	X		
Hydnaceae				X		
Hymenochactaceae	X		X	X	X	X
Podoscyphaceae			X			
Polyporaceae					X	
Punctulariaceae			X			?
Schizophyllaceae	X					
Sparassidaceae		?	X			
Stereaceae			X			
Thelephoraceae	Lenzitopsis	Thelephora	Tomentella	Hydnellum	Boletopsis	Polyozellus

"X" indicates at least one genus of the family possess this type of hymenial configuration.

b) Agaricales, adopted from the author's personal notes.
Agaricaceae, Fries
Agaricus and Melanophyllum: Endoptychum (G) and Gyrophragnum (G)
Amanitaceae, Roze
Amanita and Limacella
Bolbitiaceae, Singer
Bolbitius, Conocybe, Agrocybe; see also Panaeolus: Galeropsis (G) and Gasterocybe (G)
Boletaceae, Chev.
Boletus and segregates; Strobilomyces: Gastroboletus (G), Truncocolumella (G), and Chamonixia (G) ?

Coprinaceae, Roze
Coprinus, Psathyrella, and Lacrymaria: Montagnites (G) Panaeolus: Panaeolus: Panaeolopsis (G).
Cortinariaceae, Roze
Cortinareae: Cortinarius, Galerina, Pholiota, Thaxterogaster, and Nivatogastrium (G).
Inocybeae, Fayod: Inocybe, Hebeloma, Naucoria, and Simocybe.
Phaeomarasmieae, Singer Phaeomarasmius sensu Singer
Gomphidiaceae, R. Maire
Gomphidius and segregates: Brauniellula (G)
Hygrophoraceae, Roze
Hygrophorus and segregates
Lepiotaceae
Lepiota and Leucocoprinus (Lycoperdon??)
Cystoderma and Chamaemyces might be better in the Tricholomataceae
Paxillaceae, R. Maire
Paxillus and segregates: Paxillogaster and Austrogaster (G) Phylloporus (placed in the British Check List in the Boletaceae along with Paxillus; placed by many authors close to Boletus (Xerocomus).
Rhodophyllaceae, Singer
Entoloma, Leptonia, Eccilia, a modified Nolanea, Claudopus: Rhodogaster (G)
Secoteaceae
Neosecotium and Secotium; Endophychum
Tricholomataceae (including many laterally stipitate agarics previously placed in Pleurotaceae and those placed in the Clitopilaceae in the British Check List – an assemblage of genera many of which may be only distantly related.

Hygrophoropsoideae	Hygrophoropsis and Cantharellula
Lyophyllae	Lyophyllum etc.
Tricholomateae	Clitocybe, Lepista, Tricholoma, Melanoleuca, Laccaria, etc. Hydnagium (G) ?
Panelleae	Panellus
Crepidotaceae	Crepidotus in part, Pleurotellus
Rhodoteae	Rhodotus
Clitopileae	Clitopilus

Volvariaceae
Volvaria and Pluteus: Brauniella (G)

SYNOPSIS OF THE REMAINING BASIDIOMYCETES

Asterosporales	
Russulaceae	Russula and Lactarius: Macowanites (G) – astrogastraceous series
Auriculariales	Auriculariaceae and Phleogenaceae; incl. Auricularia and Helicobasidium
Brachybasidiales, Donk	Brachybasidiaceae; Brachybasidium
Dacrymycetales	Dacrymycetaceae; Dacrymyces, Calocera and Femsjonia

Exobasidiales	Exobasidiaceae; Exobasidium
Septobasidiales, Donk	Septobasidiaceae; Septobasidium
Tremellales	Sirobasidiaceae, Tremellaceae and Hyaloriacea; incl. Pseudohydnum, Tremella, Sebacina and Exidia
Uredinales	Melamsporaceae, Pucciniaceae, and Graphiolaceae (rusts of various higher plants)
Ustilaginales	Ustilaginaceae and Tlletiaceae (bunts and smuts of various higher plants)
Saccharomycetales	Sporobolomycetaceae; Sporobolomyces (yeast-like
Hymenogastrales (G)	Melanogastraceae, Hymenogastraceae and Hydrangiaceae
Lycoperdales (G)	Lycoperdaceae, Geastraceae, Astreaceae, Mesophelliaceae, and Podaxaceae; also see Agaricaceae above.
Nidulariales (G)	Nidulariaceae and Arachniaceae
Phallales (G)	Phallaceae and Clathraceae
Protogastrales (G)	Protogastraceae and Hemigastraceae
Sclerodermatales (G)	Calostomataceae, Tulostamaceae, Sclerodermataceae, incl. Pisolithaceae, Glioschodermataceae
Sphaerobolales (G)	Sphaerobolaceae
Hymenolichens	Dictyonemataceae; see also Tricholomataceae and Clavariaceae

There is only a limited way in which a palisade of fruiting structures can be arranged. The table below shows resemblances in the fruit-body structure in the different groups of fungi.

Hymenium configuration		BASIDIOMYCETES									ASCOMYCETES	
		Hymeno-	Gastero-	Heterobasidiomycetus							Disco-	Pyreno-
				Tremell.	Auricul.	Dacrym.						
1. lamellate or distinct ridges	Agaricus		Phallus	Exidia	Auricularia							
2. poroid	Polyporus											
3. merulioid	Merulius		Gasteria	Aporium	Protomerulius							
4. toothed-resupinate	Odontia			Proto-hydnum								
5. toothed stipitate	Hydnum			Pseudo-hydnum								
6. funnel-shaped	Craterellus			Phlogiotis								
7. club-shape	Clavaria			Tremello-dendron								
8.* resupinate smooth or sl. rugulose	Corticium		Phillorina	Phleogena								
9.* cup shape	Cyphella		Nidularia	Sebacina	Helico-basidium							
10.* tuber-like	Craterellus		Hymenio-gaster	Auricu-laria								
11.* trested	Clavaria		Gallerigaster	Tulo-stoma	Hyaloria							
12.* reduced or vestiv	Exo-basidium				Stilbum							
13.* flask-shape	Lycoperdon											
14. Jellified Pleuro-fruit-body telius			Phallo-gaster			Auricu-laria	Dacry-myces					
15. parasitic many species			Phallus									
16. symbiotic many species			Piglo-rhus									
							Castoc-era					
							Ceracea					
							Guepinia					
							Dacryo-mitra					
								Tapinina				
								Thele-tiolus				
								characteristic				
17. Bulgaria												
18. many species												
19. Pyrenulales												

10. Spores borne asymmetric on sterigmata and forcibly discharged from the basidium 36
11. Fruit-body at maturity resembling a bird's nest or simply a slippery subglobose ball within a receptacle or sac 12
11. Fruit-body not resembling a bird's nest 14
12. Bird's nest-like or simply a sac containing packets of spore producing tissue (Nidulariales) 13
12. Fruit-body with a single, slippery, internal ball containing spores **(Sphaerobolales) Sphaerobolaceae**
13. Basidia contained in numerous thin-walled packets escaping from the enclosing receptacle by it irregularly breaking **Arachniaceae**
13. Basidia contained in few to several thick-walled packets which give to the fruit-body the appearance of a bird's nest, when the enclosing receptacle opens **Nidulariaceae**
14. Outer membrane of fruit-body rupturing by expansion of the inner tissue to expose a slimy, often evil smelling, spore-mass, (Phallales p.p.)
14. Outer membrane not splitting due to rapid expansion and exposing slimy spore mass, but fruit-body usually with central simply powdery area 16
15. Fertile area of fruit-body at apex of unbranched, columnar structure, **Phallaceae**
15. Fertile area of fruit-body covering branched or lattice-like structure, **Clathraceae**
16. Fruit-body with single, regular internal hymenial layer, **Progastrales** 17
16. Fruit-body with several internal hymenial layers or if a single hymenial layer then its surface strongly convoluted 18
17. Columella absent, hymenial layer produced around a spherical central cavity **Protogastraceae**
17. Columella present, hymenial layer lining an annular cavity, **Hemigastraceae**
18. Fruit-body with lacunose internal arrangement of fertile structure, 19
18. Fruit-body with coralloid internal arrangement of fertile structure, 21
19. Fruit-body hypogeous and internal cavities filled with gelatinous matrix or with irregular masses of basidia, **Melanogastraceae**
19. Fruit-body epigeous when mature 20
20. Fruit-body with distinct fibrous to woody stem **Tulostomataceae**
20. Fruit-body lacking stem or if stalked then stem poorly differentiated or gelatinised and composed of anastomosing strands 21
21. Capillitium with annular to spiral thickenings present amongst spores, **Calostomataceae**
21. Capillitium lacking or very poorly developed, difficult to find and never distinctive, **Sclerodermataceae***
22. Fruit-body hypogeous or almost so, simple in construction 23
22. Fruit-body epigeous and often well differentiated 32
23. Columella absent 24
23. Columella present 25

*Including Pisolithaceae and Glischrodermataceae

24. Gleba fleshy **Hymenogastraceae**
24. Gleba cartilaginous to gelatinous **Hysterangiaceae**
25. Columella forming or fusing with the apical structures, no marked stem formed **Hydnangiaceae**
25. Columella forming a stem, often very well differentiated and clearly seperable at base from fertile tissue **(Secotiaceae p.p.)** 26
26. Hymenophore tube-like, spores typically boletoid **Boletaceae** in Agaricales
26. Hymenophore lacunose or irregularly lamellate, spores various 27
27. Fertile areas distinctly brown, black or purple 28
27. Fertile areas never so distinctly colored 31
28. Fertile areas some shade of brown 29
28. Fertile areas some shade of black or purple 30
29. Fertile areas brown, spores smooth, see **Bolbitiaceae, Cortinariaceae, Paxillaceae** in Agaricales (cf. **Strophariaceae**)
29. Fertile areas rich rust brown, spores ornamented, see **Cortinariaceae** in Agaricales
30. Fertile areas purple either boletoid or becoming purplish olive in KOH, see **Gomphidiaceae** and **Strophariaceae** in Agaricales
30. Fertile areas black or purple black, not boletoid and unchanging in alkali, see **Agaricaceae** and **Coprinaceae** in Agaricales
31. Fertile areas pinkish, spores irregularly angular in all optical sections see **Rhodophyllaceae** in Agaricales
31. Fertile areas pale or if with pinkish cast then spores not angular or faintly so and then only in one plane. **Secotiaceae** p.p.
32. Fruit-body stellately dehiscing 33
32. Fruit-body with irregular dehiscence 34
33. Hymenophoral chambers lacking, columella absent **Astraeaceae**
33. Hymenophoral chambers present, columella present **Geastraceae**
34. Stalk well developed, basidia occurring in clusters on glebal hyphae and the latter partaking in the final spore-mass **Podazaceae**
34. Stalk absent or poorly differentiated 35
35. Fruit-body rupturing irregularly at apex or usually with a three layered peridium, basidia borne on radially arranged hyphae **Mesophelliaceae**
35. Fruit-body dehiscing by a specialized apical pore or if rupturing irregularly then basidia borne on tremal tissue which soon disappears **Lycoperdaceae**
36. Fruit-body distinctly cup-shaped as in the 'Discomycetes' with the hymenium smooth or wrinkled, stipitate or not, cup central or lateral **('Cyphellaceae')** 37
36. Fruit-body not distinctly cup-shaped 40
37. Spore-print white or faintly colored 38
37. Spore-print darker or spores dark 39
38. Cups partially fused and grouped together so as to form an agaricoid fruitification with what appears to be splitting gills **(Schizophyllaceae)**
38. Cups if grouped together then retaining individuality never giving the appearance of an agaricoid fruitification, see **Tricholomataceae**

39. Spores ornamented, echinulate or min. verrucose, distinctly brown s.m. see **Cortinariaceae** in Agaricales
39. Spores smooth, with purplish or olivaceous flush s.m. see **Strophariaceae** in Agaricales
40. Hymenium on distinct gills, see key to Agaricales above.
40. Hymenium on the inside of tubes or depressions or on furrows or strongly anastomosing gills 41
41. Fruit-body fleshy and putrescent and hymenium borne on the inside of distinct tubes 42
41. Fruit-body putrescent or not and hymenium borne on folds, furrows, teeth or warts or if tubular then fruit-body distinctly woody.....43
42. Fruit-body small and subtropical to tropical; spore print white or faintly colored .....**Tricholomataceae** p.p.
42. Fruit-body variable, usually quite fleshy; spore print variable but never white; if yellow, then distinctly so ....**Boletaceae**
43. Hymenium furrowed with the basidia replaced by a powdery mass of chlamydospores; growing on fruit-bodies of members of the **Russulaceae**,.... .....**Tricholomataceae** p.p.
43. Hymenium if furrowed then basidia not replaced by a powdery mass of chlamydospores and fruit-body never growing on members of the **Russulaceae** 44
44. Fruit-body although possibly quite small typically toadstool-like; hymenium furrowed, or on anastomosing gills and then always lacking gloeocystidia..... 45
44. Fruit-body if with gills and resembling a toadstool then gloeocystidia present, otherwise poroid, with teeth or warts, stipitate or not 48
45. Fruit-body growing on vegetable debris, small with cap rarely greater than 20 mm broad, gills or folds considerably reduced in number..... ....**Tricholomataceae p.p.**
45. Fruit-body terrestrial cap greater than 20 mm..... 66
46. Spore print brown, hymenium on anastomosing gills or on an irregular poroid system..... ...**Paxillaceae p.p.**
46. Spore print pale, white to pale cream or with hint of pink, hymenium on less well developed gills, often simply ridges and rugulosities... 47
47. Spores smooth with very low or no affinity for cotton blue..... **Cantharellaceae p.p.**
47. Spore ornamented with high affinity for cotton blue..... **Gomphaceae p.p.**
48. Fruit-body stipitate, lamellate or distinctly toothed with distant gloeocystidia and then spores smooth or minutely puctate, or if gloeocystidia absent then fruit-body poroid or clavarioid and spores ornamented with conspicuous and strongly amyloid spines and crests.... 49
48. Fruit-body various but never lamellate and if gloeocystidia are present spores never amyloid. Then fruit-body not stipitate and spores if ornamented never with extreme amyloid ornamentation, at most spiny amyloid..... 50

49. Spores ornamented with amyloid crests and spines, gleocystidia absent; hymenophore clavarioid or with tubes..... ...**Bondarzewiaceae**
49. Spores amyloid, smooth to minutely verrucose but lacking crests or warts, gloeocystidia present. Hymenium toothed or lamellate...**Auriscalpiaceae p.p.**
50. Shelf-fungi with hymenium consisting of congregated but seperate cups or spores thick walled and amyloid.... 51
50. Fruit-body various hymenium not producing thick walled, amyloid spores and not consisting of separate cups..... 52
51. Fruit-body hard and tough with corky, orange red flesh, hymenium toothed, spores thick walled, amyloid; hyphae clamped and thick walled, dimitic ..... **Echinodontiaceae**
51. Fruit-body fleshy and juicy; hymenium consisting of separate cups, spores smooth, non-amyloid; hyphae ± clamped, monomitic and thin walled at most only slightly thickening..... ..... **Fistulinaceae**
52. Hymenium distributed on the inside of tubes and with spores non-amyloid thick walled, and complex or fruit-body various with gloeocystidial elements and spores smooth to spiny and amyloid..... ...53
52. Hymenium variable; spores rarely ever amyloid, and if gloeocystidia present then never so characterized..... 54
53. Fruit-body with tubes; spores thick walled due to complex internal structure, large, greater than 7 mm in length and spore print brown. .... **Ganodermataceae**
53. Fruit-body variable; spores amyloid, globose to ovoid, faintly ornamented small to minute (3.5 to 6.5 mm), spore print white.... **Hericiaceae**
54. Spores smooth although uneven in outline, brownish to olivaceous, less frequently buff in print or if eliptic and smooth hymenium crisped or consisting of curved plates which infold on drying.... 55
54. Spores if uneven in outline then distinctly ornamented, white or faintly colored in mass; gills when present never crisped.... 56
55. Spores white or faintly colored, smooth and not irregular in outline, hymenium crisped or on 'splitting' gills.... **Schizophyllaceae p.p.**
55. Spores ornamented, brown or if pale then outline uneven... **Thelephoraceae**
56. Hymenium dispersed on cushions scattered over fruit-body and separated by sterile tissue and irregular fissures, or fruit-body cauliflower-like, a mass of flattened, crisped or waxy lobes with or without fertile base. 57
56. Hymenium regularly distributed on fruit-body, or if fruit-body consisting of branched club-shaped structures then not forming a cauliflower-like mass..... 58
57. Hymenium on the underside of flattened, crisped and waxy lobes or amphigenous on irregular ascending structure; flesh not or indistinctly stratified..... ... **Sparassidaceae**
57. Hymenium layer gelatinized, basidia distributed on small cushions which are separated by sterile tissue and irregular fissures filled with

chemical deposits; flesh distinctly stratified..... ...**Punctulariaceae**

58. Fruit-body stipitate, hymenium on distinctly toothed structures; spores smooth or ornamented with low or no affinity for cotton blue... 59
58. Fruit-body if stipitate then hymenium not on toothed structure unless spores have high affinity for cotton blue and are then distinctly ornamented.... 60
59. Fruit-body with strongly aromatic odor, particularly when dry; spores sub-globose, echinulate and spore print white..... **Bankeraceae**
59. Fruit-body inodorous or odor if present never aromatic; spores sub-globose to ellipsoid, smooth and spore print whitish or buff... **Hydnaceae**
60. Fruit-body funnel shaped or club shaped and basidia 2-spored; spores with high low or no affinity for cotton blue.... 61
60. Fruit-body various, if funnel shaped then woody, or if club shaped then basidia 4-spored and spores with little or no affinity for cotton blue..63
61. Basidia 2-spored; fruit-body club shaped, branched or simple, smooth rugulose or rugose, pale or dull colored (white or grey). If basidia 4-spored then spores large and globose..... **Clavulinaceae**
61. Basidia variable, up to 9-spored; fruit-body strongly branched to funnel shaped or almost agaricoid, distinctly often strongly pigmented.....62
62. Spores smooth with little or no affinity for cotton blue, fruit-body neither clavaroid nor green with FeSO4 ..... **Cantharellaceae p.p.**
62. Spores ornamented and with high cotton blue affinity; fruit-body green with FeSO4, funnel shaped or clavariod branched..... **Gomphaceae p.p.**
63. Setae present, dark colored in KOH or if fruit-body lacking setae then consisting of simple or branched club shaped structures (clavarioid) and hymenium amphigenous 64
63. Setae absent; fruit-body never clavarioid and hymenium never amphigenous.65
64. Fruit-body club shaped; hymenium amphigenous ..... **Clavariaceae**
64. Fruit-body possessing setae; hymenium not amphigenous....**Hymenochaetaceae**
65. Fruit-body distinctly poroid, pores regular to irregular, small to large; spores white or slightly colored, typically non-amyloid rarely pseudo-amyloid and more rarely amyloid ....**Polyporaceae p.p.**
65. Fruit-body smooth, irregular, tuberculate or toothed.... ...66
66. Fruit-body smooth, toothed or tuberculate, effused to poorly pileate, soft, monomitic but with strongly thickening hymenium; spores brown, double walled with strong affinity for cotton blue.... **Coniophoraceae**
66. Fruit-body smooth to tuberculate, tough or if soft then structures dimitic; spores neither brown nor double walled nor with a high affinity for cotton blue..... 67
67. Fruit-body adpressed or effuse-reflexed, sessile or stalked, usually flattened throughout with strictly one sided hymenophore, leathery, woody, or corky; spore print pale. **Stereaceae**

67. Fruit-body variable, typically effused never stipitate, waxy, cottony, membranaceous, gelatinous but never leathery, tough, spore print white to distinctly colored..... 68
68. Metabasidium ± separated by a wall from the sterigmata; epibasidium inflated above or below middle..... ....**Tulasnellaceae p.p.**
68. Metabasidium eseptate, lacking wall at base of sterigmata, clavate to fusiform never inflated..... 69
69. Fruit-body waxy, cottony, membranaceous or gelatinous; hymenium when irregular on cushions, papilla, or rugulosities.....**Corticiaceae**
69. Fruit-body soft variable but with pits, tubes, and depressions forming in some part of hymenium..... ...**Polyporaceae p.p.**
70. Basidia tuning-fork shaped with apical portion each equal in length to the basal part, 2-spored..... **Dacrymycetaceae (Dacrymycetales)**
70. Basidia not tuning-fork shaped and if 2-spored then sterigmata short and distinctly septate or cells disproportionate in size... ...71
71. Basidia eseptate with or without a wall separating the sterigmata; epibasidium inflated above or below middle .... 72 **(Tulasnellales)**
71. Basidia septate, more rarely eseptate and if so developing from or into a thick walled cell or propagule; epibasidium if present rarely swollen and then only at apex.... 73
72. Epibasidium swollen, globose to ventricose-cylindrical with septum separating it from hypobasidium... **..Tulasnellaceae p.p.**
72. Epibasidium confluent with hypobasidium... **...Ceratobasidiaceae**
73. Basidium longitudinally or obliquely septate... ....74 (Tremellales)
73. Basidium transversly septate or eseptate... 75
74. Basidia catenate; epibasidium lacking.... **....Sirobasidiaceae**
74. Basidia not catenate; epibasidium present.... 76
75. Spores asymmetric on mucronate sterigmata.... **... Tremellaceae**
75. Spores symmetric on filiform sterigmata.... **... Hyaloriaceae**
76. Fungus saprophytic, infrequently parasitic on plants; basidia not arising from thick walled cells.... 77
76. Fungus parasitic on vascular plants; basidia arising from thickened cells. See Rusts, Smuts and Bunts; not further dealt with here.
77. Fungus parasitic on insects or forming a symbiotic relationship, fruit-body rarely gelatinous; hypobasidium well developed often thickened, rarely absent and epibasidium one to four celled.... **Septobasidiaceae (Septobasidiales)**
77. Fungus associated with plant material, simply saporphytic, rarely parasitic; fruit-body various, basidia lacking thickened structures..78. **(Auriculariales)**
78. Fruit-body dry with stalked head; basidia hardly or not differentiated into hypobasidium and epibasidium and separated one from another by coiled or curved hyphae.... **...Phleogenaceae**
78. Fruit-body saprophytic less frequently parasitic, characteristically gelatinous confluent, sessile, resupinate; basidia frequently although not always separable into hypo- and epi-basidium..... **Auriculariaceae**

79. Spores always forcibly dispersed, produced from thick walled spores (teliospores) which may be single or compound, united into crusts or columns; frequently several types of propagule produced by the one fungus. Thallus although reduced remaining filamentous and fairly complex in fruit body construction; typically septate basidia.... ... 80 **(Uredinales)**

79. Spores not violently dispersed except in one group, produced from thick walled cells as single or united columns or balls; rarely more than one type of propagule produced by the one fungus. Thallus much reduced and frequently budding in much the same way as yeasts; basidia often reduced and identified only by analogy..... ... 81 **(Ustilaginales)**

80. Teliospores formed in the outer layers of the host or united into crusts, cushions or waxy columns, lacking stalks and produced singly or in groups of 2 to 4; aecidiospores frequently parasitising conifers.. **Melampsoraceae**

80. Teliospores stalked, simple or compound on a common stalk or held together in gelatinous masses, rarely sessile and then produced as simple or compound units which escape dry or embedded in slime; hosts various, aecidiospores rarely produced on conifers.... .... **Pucciniaceae**

81. Promycelium present; walled teliospores intercalary or arising as lateral outgrowths from hyphae or originating from transformed hyphae within the host tissue; fruit-body never cupulate; hosts various.... 82

81. Promycelium absent, teliospores in compact sori; and formed in vertical rows interspersed with sterile hyphae budding to give four sporidia which form thick dark walls; fruit-bodies cup-like; on palm leaves. **Graphiolaceae**

82. Promycelium septate forming a series of cells usually four in number each producing a single spore; teliospores formed within host tissue, and never expelled forcibly, coidia absent.... .... **Ustilagnaceae**

82. Promycelium eseptate, simply producing four to many cells (spores) at apex; teliospores intercalary or as lateral outgrowths and formed within host tissue; conidia also produced and expelled from conidiophores. **Tilletiaceae**

HINTS on the MICROSCOPICAL EXAMINATION of the AGARIC FRUIT-BODY

ROY WATLING
(Royal Botanic Garden, Edinburgh)

1. In the Laboratory –

Note the fresh colours and textures as suggested by all authoriatative texts. Making a sketch, coloured if possible, is of great use for on drying the material will shrink and lose most of its colour and shape. Table one is included to assist in deciding in what order to examine the fruit-body.

Instrumentation

Once the external features have been described the microscopic characters can be sought; the series of steps described below and their accompanying sketches show how the problem of examining the specimen to see its microscopic structures should be tackled. Two scalpels, or two razors broken to different sizes, fine forceps, and a needle are all that is required; only with a woody fungus does one have to resort to any force, but even then the principles are the same.

A good student's microscope is all that is required to see the structures which will be described in this paper. Low- and high-power dry objectives are most frequently used and only when examining in detail or measuring spores, hyphal filaments and cystidia is an oil-immersion objective required.

Preparation of fresh material

Figure one shows the cuts required to furnish suitable sections. Figures 2-10 illustrate various structures and patterns of tissue which should be noted.

1. Carefully make a complete longitudinal section (AB) of the fruit-body –draw this. Place gill-face down under a low-power or dissecting microscope. Cystidia on the cap, if present will be made visible by focusing up and down (Fig. 2 and/or stem Fig. 3). When any part of the cut fruit-body is not being examined retain it in a chamber containing damp paper or moist moss; this will assist the cells in retaining their turgidity, for they frequently collapse on drying and are difficult to observe except after performing often lengthy and special techniques.

If only one fruit-body is available then cut along CD and mount in a tin box on a slide in order to obtain a spore-print (otherwise see 6).

2. Cut off a complete gill (E) and quickly mount on a dry slide. Under the low power of a microscope, the cystidia on the gill margin will be visible (Fig. 4); it will also be seen whether the spores are arranged in a particular pattern (Fig. 5) and whether the basidia are 2-spored or 4-spored. In white-spored toadstools it is difficult sometimes to determine whether the basidia are 2- or 4-spored so one must confirm the observations by other techniques (see below).

A section of the gill accompanied by a small piece of cap tissue as in E will

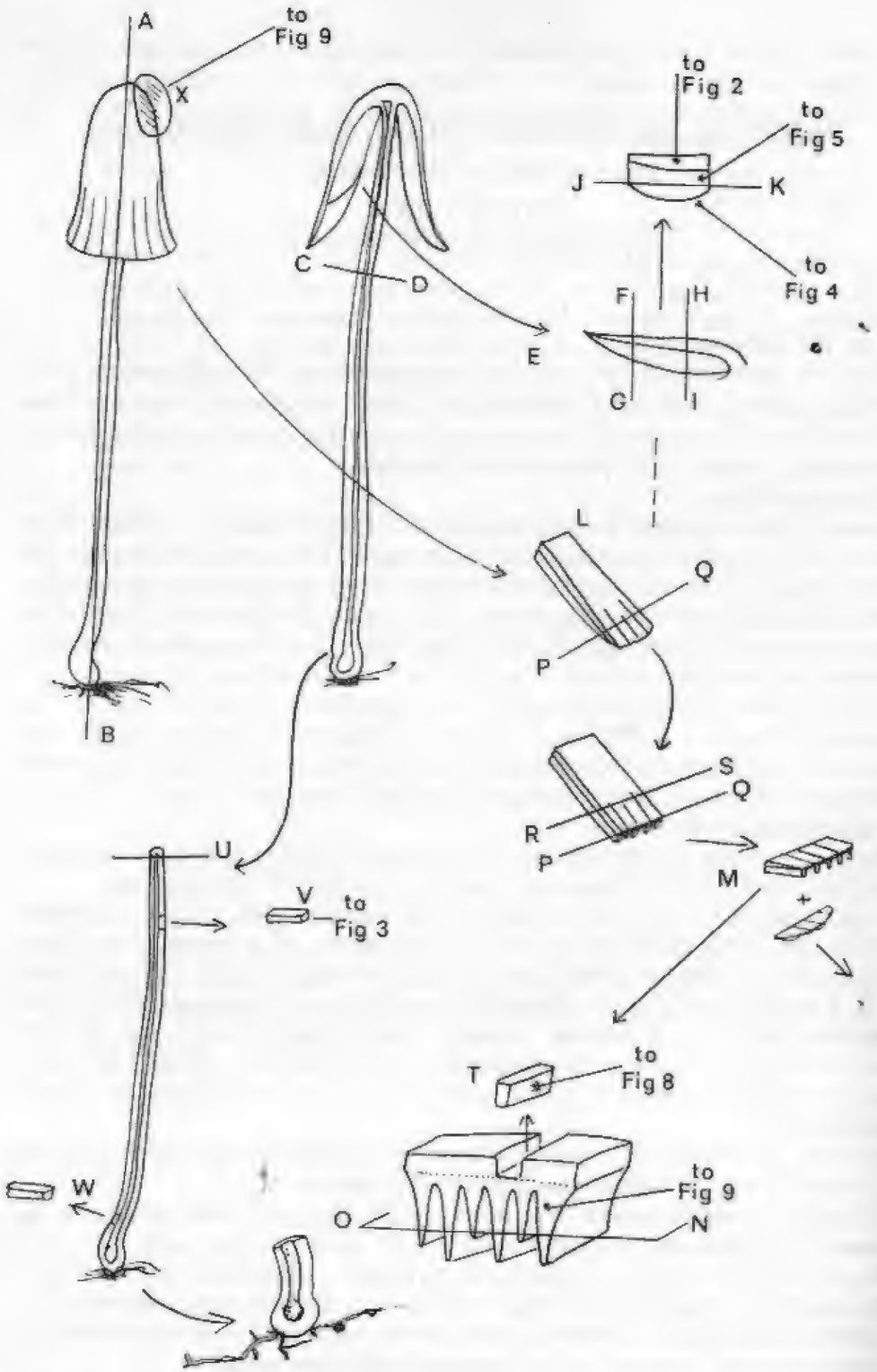


FIG. 1. The dissection of a toadstool as recommended by the author. For explanation see text.

confirm the presence or absence of noticeable cystidia on the cap. Now mount the section bounded by FG and HI in a drop of water containing either a drop of Teepol and/or glycerol; the Teepol helps to expel any water which may tend to cling to the gill-margin amongst the cystidia and the glycerol stops the mount from drying out whilst further sections for comparison are cut and examined. It is at this time that the structure of the outermost layer of the cap can be examined, e.g., whether it is made up of turf-like structure; the presence or absence of pileo-cystidia can be also confirmed (Fig. 2). It is frequently necessary to tap the mount in order to spread the tissue slightly and expose the elements; this can be done very efficiently by light pressure from the end of a pencil to which an eraser is attached. Cut off along line JK to eliminate cheilocystidia from confusing the picture and mount both pieces separately.

3. Cut out a wedge of tissue from the fruit-body (L) so as to have several gills attached to some cap tissue; until one is familiar with the variability of facial and marginal cystidia, carefully cut along PQ (note: the cut is made one-third of the distance from the cap margin, thus eliminating the possibility of large numbers of marginal cystidia being examined in error and appearing as if they were facial elements). Mount second portion of tissue similarly.

Mount on a dry slide with the plane through PQ face down on the slide and observe under a low magnification, which will allow one to assess whether cystidia on the gill face are present or absent, and if present their general shape and whether numerous or infrequent (Fig. 6).

Mount in water/Teepol mixture as outlined above and tap gently with the rubber attached to the end of a pencil; even pressure should be given. If the gills appear to be too close, then rotate the rubber a little whilst pressing in order to spread the tissue.

4. Using a low power of a microscope and looking down into the plane RS of the unmodified block M or a similar block, one obtains by this simple technique a very accurate idea as to the structure of the hymenophoral trama (Fig. 7). The organization of this tissue is very important in classification, some groups of toadstools having what has been described as regular trama (Fig. 7c) others irregular (Fig. 7d), inverse (Fig. 7b) or divergent [=bilateral (Fig. 7a)]. This same tissue may be thick or sparse to wanting, coloured or not. Such sections are often better than attempts at very thin sections unless either paraffin or freezing-microtome sections are made. Very thin sections of the cap produced by hand often show the drag effect of the razor edge and this is far more disastrous to the mount than if the specimen was a piece of flowering plant material; there are few satisfactory thicknesses between the two extremes.

5. Take out a small block of tissue T as indicated in the figure (Fig. 1). Mount immediately and repeat as in 3. This will allow the outer layer of the cap to be more clearly seen (Fig. 2) and also the structure of the flesh (Fig. 8). The latter may be composed of a mixture of filaments and "packets" or "nests" of rounded cells (i.e., heteromerous) or of filaments, only some of which may be inflated; but when individual cells are swollen they never form distinct groups (i.e., homoiomerous). It is by very similar techniques that the polyporaceous fungi were shown to have flesh composed of one of four tissue types depending on whether

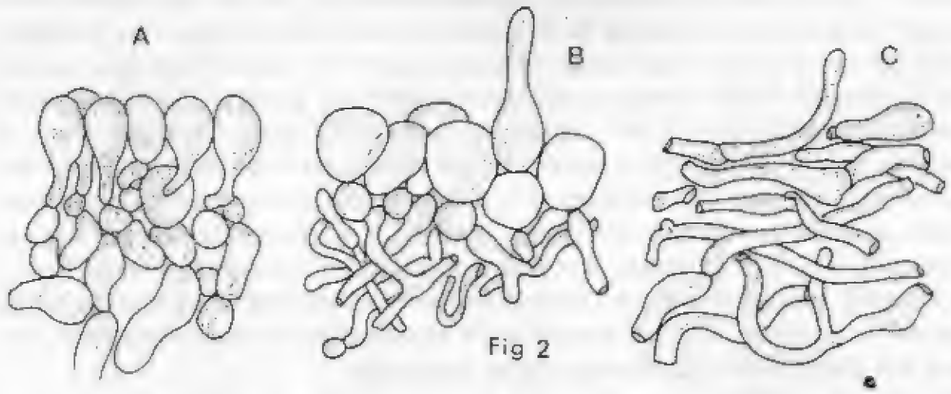


Fig 2

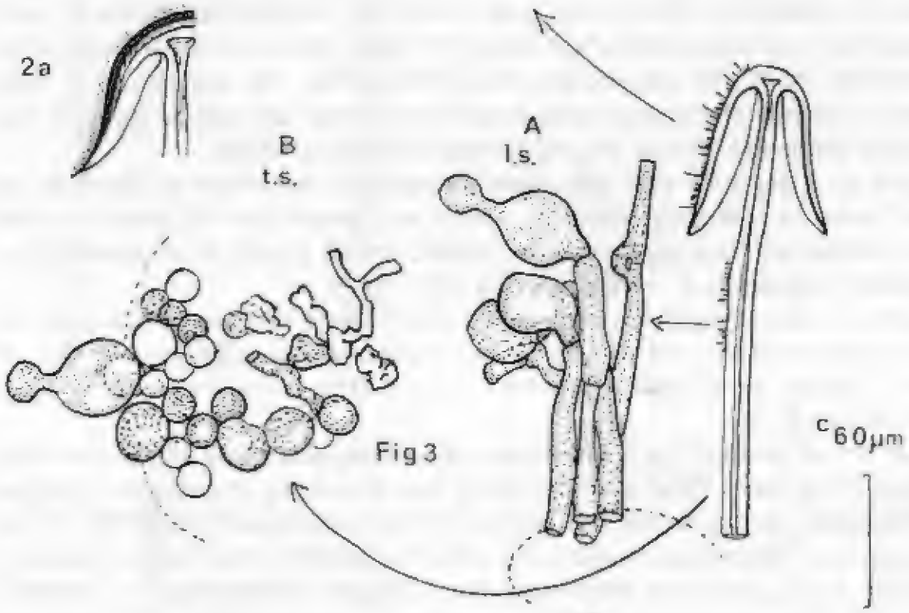


Fig 3

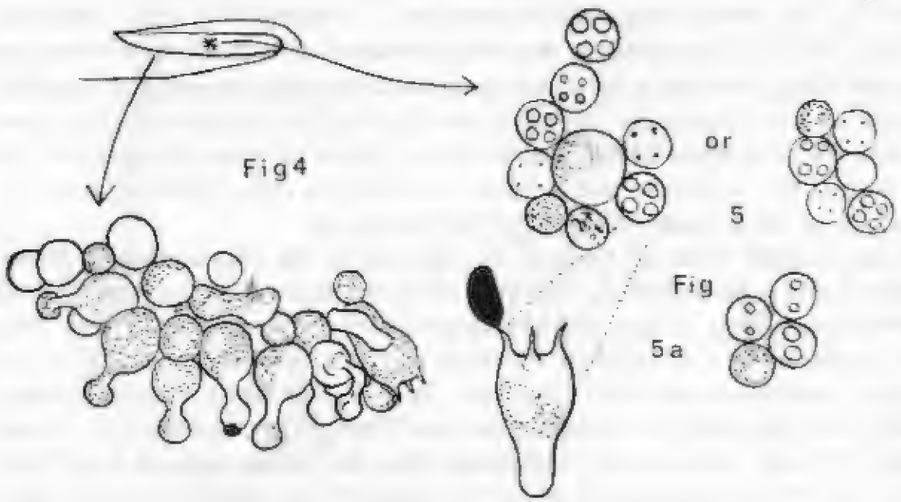


Fig 4

distinctly thickened cells are present with the actively growing hyphae or not, whether hyphae are present which bind groups of hyphae together, etc.

6. Remove stem along line CD and remove small blocks of tissue as indicated (U, V and W). Mount immediately and examine as in 3 for cystidia, etc. (see Fig. 3).

Whilst all these sections are being cut and processed a second fruit-body, if available, should be set to drop spores; this is done by cutting off the cap from the stem and placing it either entirely or in part, and with gill-edges down, on a slide in a tin.

7. X is a "scalp" of a cap; a thin sliver from the cap is placed on a slide in a drop of water (modified with Teepol, etc., as above). After placing a coverslip over the tissue it is tapped gently; this will show if the cap is composed of globose to elliptic elements or if it is composed of strictly filamentous units (Fig. 9). Care must be taken not to reverse the section when transferring to the mountant, either by turning the scalpel or by allowing the surface tension of the liquid to pull the section upside down. The construction of any veil fragments will also be seen in this mount.

8. Examine the stipe of the fruit-body used above under a low power or with a dissecting microscope in order to ascertain whether there are any remains of substrate, veil and/or vegetative mycelium. If found, mount immediately in Melzer's solution and examine.

Herbarium material and chemical reagents

With dried material the same procedure described above is carried out by mounting directly in fluid and examining under high power dry- and oil-immersion objectives and so dispensing with the use of the lower magnification. With such material it is, however, very necessary to allow the tissue to return to something like its original state by incubating for not less than five minutes in a 5·0 per cent aqueous solution of ·880 SG ammonia (some people prefer a dilute solution of caustic potash or caustic soda: stronger solutions are used when studying the reactions of the flesh of fruit-bodies). Frequently colour reactions of the tissue take place when chemicals are used, e.g., with alkali many species of **Gymnopilus** release a deep chrome yellow pigment, certain species of **Hydnum** appear to have blue black granules on the hyphae in caustic potash, whereas the cap tissue of certain species of **Conocybe** (particularly those of the subgenus **Pholiotina**) become a beautiful cinnamon brown. The alkali simply swells the tissue to approximately the size and shape it was when the fruit-body was fresh.

FIG. 2 A. longitudinal section of ' cellular cuticle ' of *Conocybe* sp. B. l.s. of cellular cuticle ' of *Coprinus* sp. C. l.s. of filamentous ' cuticle ' of *Galerina* sp.

FIG. 2a Sketch to illustrate the various zones of the cap tissue: a viscid layer which may be present or absent, the outermost layer (' cuticle '), the underlying tissue (subcutis) and the flesh (medulla or pileus trama).

FIG. 3. A. l.s. of stem of *Conocybe* sp. showing caulocystidia and cylindrical hyphae constituting cortex of stem; B. transverse section of stem of same species showing caulocystidia and cross-section of hyphae.

FIG. 4. Gill-edge of *Conocybe* sp. showing group of cheilocystidia.

FIG. 5. Pattern produced by developing basidia, separated or not by specialized cells (pleurocystidia), and observed when looking down on to the gill-face.

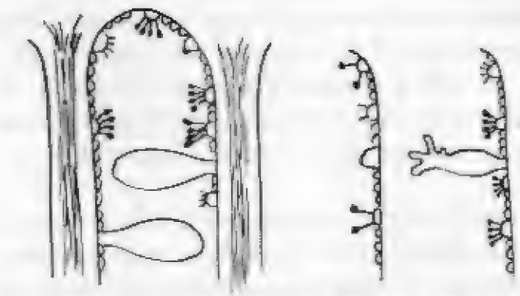


Fig 6

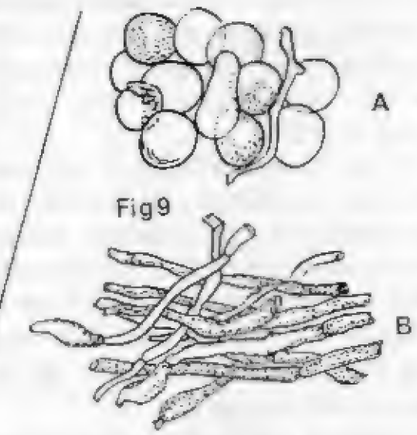


Fig 9

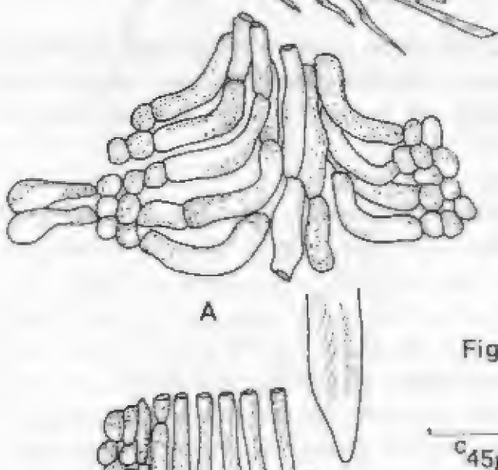


Fig 7

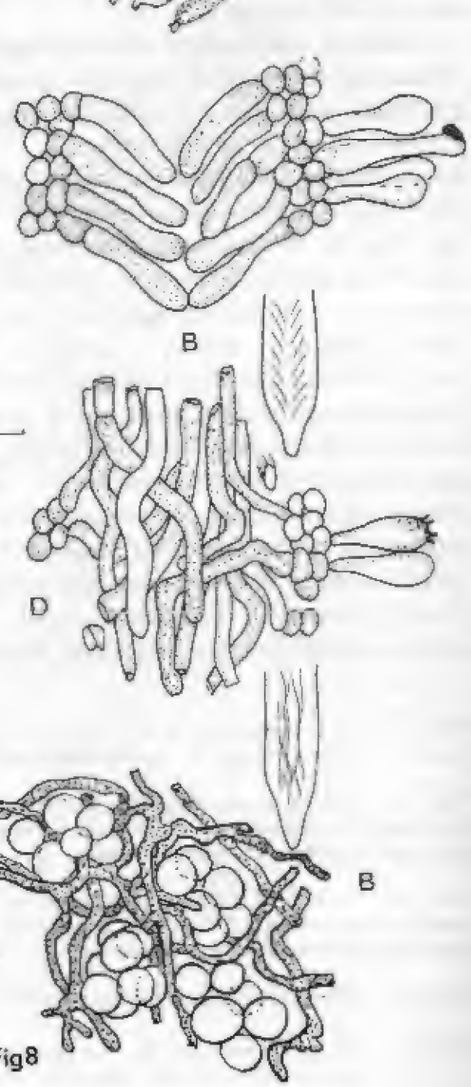


Fig 8

Influxing mounts of fresh or dried material with a solution of cotton blue or of trypan blue helps to accentuate areas and allows one to pick out actively growing hyphae, and gelatinised or thickened walls. American mycologists prefer an alcoholic solution of phloxine to cotton blue and this colours the material, and removes unwanted air in one stage.

Cresyl blue (Kühner, 1934) when influxed into the section accentuates the tissue containing mucilage. Melzer's solution, stains so-called amyloid material grey, blue, indigo, blue black or purple blue and "dextrinoid" material a rich red brown; a negative reaction or a pale golden colour is said to be non-amyloid. The Melzer's reaction is very important, for amyloidity of the flesh or of the spores, or both, are used as key characters. In certain members of the family **Tricholomataceae** and **Cortinariaceae** the basidia and often other cells appear to be filled with little black to dark purple granules when mounted in acetocarmine. The presence or absence of these granules is used in the classification of the white-spored agarics; they are known as carminophilic granules.

Oxalate crystals occur in and on the cells of fungi. As oxalates are soluble in mineral acids, treatment with approximately 60 per cent aqueous cold hydrochloric acid allows one to distinguish between crystalline material, detritus, and actual structural ornamentation of the cell wall, a technique necessary when studying the veil constituents of **Coprinus** spp. It must be stressed, however, that not all crystalline material is oxalate, regardless of what is so frequently reported in the texts.

Dried material can be treated with a whole array of chemicals to accentuate certain microscopic structures (Singer, 1962). Ammonia will stain certain types of pleurocystidia yellow, and because of their reaction, such cystidia have been termed chrysocystidia; they are often more obvious in dried material than in fresh fruiting bodies.

FIG. 6. Starting from block of Fig. 1, the gills separated as outlined in the text; the sketches illustrate the patterns observed when looking down amongst the separated gills, e.g., pleurocystidia, 2- or 4-spored basidia.

FIG. 7. Gill trama types: A. divergent. B. inverse. C. regular. D. irregular.

FIG. 8. Flesh types: A. homoiomerous with a single lactiferous hypha (*Boletus*). B. heteromerous (*Russula*).

FIG. 9. Cap ' scalp ': A. ' cellular ' with subglobose to elliptic constituents (*Bolbitius*). B. ' filamentous ' with purely filamentous units (*Galerina*).

CHARACTERISTICS FOR THE IDENTIFICATION OF PILEATE HIGHER FUNGI

Locality — Grid reference
Habitat notes — Soil type — pH
Vegetational community — Solitary, troops, rings

Macroscopic characters
(a coloured illustration or line sketch is preferable; a vertical section showing the gills, flesh, etc., is very useful)

CAP
General characters –
diameter — shape — consistency
colour when mature — when immature
colour when wet — (hygrophanous, expallent or not)

'Cuticle' –
dry, moist, greasy, viscid, glutinous — peeling easily or not
smooth, matte, polished, rough, hispid, pubescent, velvety, scaly, etc.

Marginal characters –
regular, wavy — incurved or not
smooth, rough, sulcate — striate or not
Veil (if present) –
colour — consistency — abundance and distribution
if marginal — filamentous, appendiculate, dentate

[GILLS] (or pores, teeth, etc.) –
remote, free, adnate, emarginate, subdecurrent, decurrent
crowded or distant — distinctly forked or not
interveined or not — separable from cap or not
consistency — (brittle, pliable, fleshy, waxy)
thickness — width — shape
number of lengths — colour when immature — at maturity
gill-edge characters

STEM –
central, eccentric, lateral, lacking — length
thickness — hollow or not
consistency — (fleshy, stringy, cartilaginous, leathery, woody)
colour when immature — at maturity
surface characters — (dry or viscid, fibrillose, striate, scaly, smooth)
(Include characters of base)
volva, if present — veil, if present
ring, if present — (single or double; membranous or persistent; fugacious; mobile; superior or inferior)

FLESH –
colour in cap when wet — when dry
colour in stem when wet — when dry
colour changes, if any
presence of latex or not: if present colour on gills and on handkerchief

TASTE –
of cuticle — of flesh

SMELL –
before cutting — after cutting

CHEMICAL REACTIONS (of flesh)
10% aq. $FeSO_4$ — 10% aq. NaOH — 10% aq. NH_4OH
Conc. mineral acids — 2% aq. Phenol — Melzer's reagent
Aniline water or Aniline oil (inc. Schaeffer's reaction)
40% aq. formaldehyde

Microscopic characters (add drawings)

BASIDIOSPORES –
colour in mass — colour under microscope — amyloidity
shape — size — ornamentation
germ-pore: shape, size, position
apiculus: shape, size, position

BASIDIA –
shape, size — sterigmata number and size

PILEUS TRAMA –
type of cells

GILL TRAMA –
type and arrangement of cells

PILEUS SURFACE –
type of cells making up outermost layer
presence or absence of cystidia

STIPE SURFACE
presence or absence of cystidia and/or hairs

CYSTIDIA –
Presence or absence on gill-face
special features: shape, size, thickness of wall, pigmentation if any
presence or absence on gill-edge
special features: shape, size, thickness of wall, etc.

KEY OF NORTHEASTERN AMANITA

by René Pomerleau'

The genus **Amanita** Persoon ex Hooker (1821) comprises the best known mushrooms in the world, mainly because some of them are deadly poisonous, others dangerous or hallucigenous, and a few were considered for a long time as the best edible kinds, such as the Ceasar's mushrooms. In addition they are often very attractive, and, on account of their complex structure and their association with trees, they are choice study material.

More than one hundred species of Amanitas, occuring mainly in the temperate zones, are described in the world, but probably many others will be found in tropical countries. In Quebec, I have found only 24 species, but several others occur in eastern United States, particularly south of the Mason Dixon line. European species have been described and listed long ago. In North America, Schweinitz and Peck have recognized a number of already known species and named several new ones. Atkinson (1900), Kauffman (1918), Murril (1913) and Coker (1917) have distinguished and named a few others. In a comprehensive study on the section **Lepidella,** Bas (1969) has reviewed the material gathered in North America and proposed new names for a number of entities.

This group of fungi is mainly characterized by their fleshy carpophore composed of a circular cap and a central stipe, both usually showing, at maturity, remnants of two veils, and by their free gills, producing a white spore-print. When young, the carpophore is covered by a universal veil, which leave a volva at the base of the stipe and often warts on the cap. A partial veil, which overlayed the gills at first, usually remains as a ring near the top of the stipe and as patches on the margin of the cap. The stipe is often bulbous and is readily reparable from the cap by a neat split. Gills are free from the stipe or reach it only by a thin line. Spores are white in mass, hyaline under the microscope, smooth, round, oval, elliptical or almost cylindrical. The gill trama is bilateral and the hymenium without cystidia.

The name **Amanita** is applied to species having the above-mentioned features since 1821 (Hooker), following the separation made earlier (1797) by Persoon from the genera **Agaricus.** The name **Amanitopsis** (1876) given by Roze to species without an annulus, has been rejected by Patouillard (1900). However, it was difficult to find affinities between species and to established subgeneric groups until the discovery by Gilbert and Kühner (1928) of the amyloid reaction of the spore membrane. The modern classification is based largely on the work of Gilbert (1940 and 1941) who used the spore membrane reaction, the spore form, the texture of the universal veil and the persistance of the partial veil as the main characteristics for the distribution of species into a number of genera. The same arrangement is followed in this key, but the divisions have been reduced to the level of section.

This key prepared for species known to occur in Quebec, can be used in most of northeastern America. In the southeastern states, up to Massachusetts, a number of species have been found and named. However, their status being either uncertain or recently established (Bas 1969) they are not included in the present key but are tentively listed in the descriptive part.

KEY TO SECTIONS AND SPECIES

1 – Spores non-amyloid; cap margin clearly sulcate or striate 2
1 – Spores amyloid; cap margin even or faintly striate 13
2 – Stipe without visible annulus (Sec. **Amanitopsis**)..... 3
2 – Stipe with a persistant or fugacious annulus 6
3 – Volva membranous and composed of filaments 4
3 – Volva floccose, thick, composed of large spherical elements... 1. **A. inaurata**
4 – Tall species; cap copper brown, dark gray brown on the umbo and toward the margin, brownish or paler elsewhere..... 2. **A. umbrinolutea**
4 – Medium or small species; cap differently colored 5
5 – Cap slate gray or bluish gray..... 3. **A. vaginata** v. **typica**
5 – Cap fulvous, chestnut or rusty colored..... 4. **A. vaginata** v. **fulva**
5 – Cap white or whitish..... 5. **A. vaginata** v. **alba**
6 – Volva membranous and persistant (Sec. **Amanita**)..... 7
6 – Volva floccose and fugacious (Sec. **Amanitaria**)..... 8
7 – Cap umbonate, deep red or orange red; stipe and gills yellow; volva white, large and almost entire..... 6. **A. caesarea** v. **americana**
7 – Cap convex, pale or dark brown; stipe white or grayish; volva sheating and lacerated..... 7. **A. spreta**
8 – Spores spherical or shortly oval 9
8 – Spores elliptical 10
9 – Cap gray, mealy or dusty with a grayish meal or dust.... 8. **A. farinosa**
9 – Cap yellow or orange, with floccose and yellow warts.... 9. **A. frostiana**
10 – Medium species 11
10 – Large species..... 12
11 – Cap orange or rosy-colored, with floccose and pale yellow particles..... 10. **A. wellsii**
11 – Cap whitish, cream-colored or pale grayish, with or without veil patches..... 11. **A. gemmata**
12 – Cap red, orange or yellow, with floccose, whitish or yellowish warts..... 12. **A. muscaria**
12 – Cap pale brown or whitish on the disc, paler toward the margin, with pyramidal and whitish warts..... 13. **A. cothurnata**
13 – Volva membranous or semi-membranous 14
13 – Volva floccose and often fugacious 20
14 – Spores elliptical or cylindrical (Sec. **Amidella**)..... 15
14 – Spores spherical or shortly ovate 16
15 – White species; cap smooth, but partly covered with floccose and white squamules or debris, mostly on the margin; volva thick and white..... 14. **A. peckiana**
15 – Reddish brown species; cap scaly or squamulose; volva membranous and reddish brown..... 15. **A. volvata**
16 – Bulb round and not marginated (Sec. **Phalloidae**)..... 17
16 – Bulb marginated and flattened (Sec. **Mappae**)..... 18

17 – Tall species, white; cap campanulate and umbonate; stipe stout and fibrillose; bulb ovate.... 16. **A. virosa**
17 – Smaller species, white; cap convex; stipe slender; bulb round and somewhat flattened..... 17. **A. bisporigera**
18 – Tall species; cap brown olivacious; virgate, at times whitish; stem stout, white and soon brownish stained; bulb large, marginate and split vertically..... 18. **A. brunnescens**
18 – Smaller species and differently colored 19
19 – Cap yellow or pale yellow, with a few white warts or patches ..... 19. **A. citrina**
19 – Cap violaceous brown or grayish brown; covered with gray pulvelulence; stipe whitish and marked with gray or dark fibrills.... 20. **A. porphyria**
20 – Flesh becoming reddish stained, mainly at the base of the stipe (Sec. **Amplariella**)..... 21
20 – Flesh unchanged 22
21 – Medium or tall species; cap whitish or brownish, reddish stained and covered with gray warts..... 21. **A. rubescens**
21 – Medium or small species; cap lemon yellow or brownish yellow, covered with yellow warts..... 22. **A. flavorubens**
22 – Stipe subbulbous or with a small bulb.... 23
22 – Bulb stout and rooting 24
23 – Volva and warts yellow.... 23. **A. flavoconia**
23 – Volva and warts grayish; cap umber brown or whitish... 24. **A. spissa**
24 – Tall and/or medium species, pale brown; bulb large and turnip shape.... 25. **A. atkinsoniana**
24 – Medium or small species; cap with pyramidal and gray warts; bulb long and rooting..... 26. **A. onusta** (?)

BRIEF DESCRIPTIONS AND OBSERVATIONS

Genus AMANITA Persoon ex Hooker

Saprophyte, terrestial, stipitate, fleshy, angiocarpous; cap separable, glabrous or warty; gills free; gill trama bilateral; stipe with a persistent or fugacious annulus, bulbous or not; volva membranous or floccose, persistent or fragile; basidia 4- or 2-spored; cystidia absent; spores white in mass, spherical, oval or elliptical, amyloid or not.

Subgenus EUAMANITA Konrad et Maublanc

Spores non-amyloid; cap margin striate or sulcate.

Section AMANITOPSIS Roze emmend Gilbert

also named **Vaginatae** (Fries) Quélet

Annulus absent or vestigial; bulb absent; volva membranous, floccose or friable; cap margin sulcate; spores spherical, non-amyloid.

1. **A. inaurata** Secretan

Usually large and gray species; cap conical or campanulate, with floccose and gray warts; margin sulcate; stipe long and stout, gray and squamulose; volva floccose friable, gray, composed of large round cells; spores spherical.

Occasional in deciduous and mixed woods; also on shaded lawns.

A small white form is also found, but its volva is friable and composed of large round cells. Gilbert has called it **forma specialis americana.**

2. **A. umbrinolutea** Secretan

Tall species; cap umbonate, campanulate, copper brown on the disc and toward the margin; volva membranous, white, composed of filaments.

Rare in conifer stands.

3, 4 and 5. **A. vaginata** (Fries) Vittadini

Medium species; cap convex, umbonate, deeply sulcate at the margin; stipe slender, not bulbous; volva membranous, white.

Cosmopolitan and very common in woods, thickets and fields.

Three varieties are recognized in America:

typica Kühner & Romagnesi (**livida** Peck): cap bluish gray;
fulva Gillet: cap fulvous, tawny or rusty;
alba Gillet: cap white

Other varieties are also known in Europe.

Section AMANITA Gilbert

Annulus membranous; bulb absent; volva membranous and persistent; cap sulcate at the margin; spores elliptical, non-amyloid.

6. **A. caesarea** (Fries) **Schweinitz** var. **americana** Gilbert

Large species; cap convex and umbonate, deep red at first, orange red and orange at the end, sulcate at the margin; gills golden yellow; stipe stout, cylindrical, yellow; annulus large, yellow or orange; volva membranous, large, entire, persistent, white; spores elliptical.

The beautiful Ceasar's mushroom occurs during summer in certain oak stands and occasionally in other woods.

The American variety differs from the European type only by a very distinct umbo on the cap.

7. **A. spreta** Peck

Large species; cap convex, more or less striate at the margin, umber brown; gills white or cream colored; stipe stout, fibrillose, cylindrical, whitish; annulus membranous, umber brown below, white above; volva membranous, white, persistent; spores elliptical.

Rare in Quebec, in mixed woods, growing under pines and oaks in eastern and central United States.

A. cokeriana Sing. (**A. recutita** sensu Coker) may be a form of **A. spreta.**

Section AMANITARIA Gilbert

Stipe annulate, bulbous; volva floccose, thick, forming a sheat on the stipe and leaving warts on the cap; spores round, oval or elliptical, non-amyloid.

8. **A. farinosa** Schweinitz

Small species; cap covered with grayish dust or flakes; margin striate, stipe usually without an annulus, dusty and with a small bulb; spores round, oval or elliptical.

Rare in deciduous forests.

This interesting small species, mainly collected in the southeast, has been found once in Quebec. The inclusion of this species in a district section (**Amanitella** Gilbert, **Ovigerae** Singer) appears unjustified.

9. **A. frostiana** Peck

Medium or small species; cap orange or yellow, with yellow warts or patches; margin faintly striate, stipe bulbous, yellow or white; volva floccose, yellow; spores round or oval.

Rare in Quebec in mixed woods and conifer stands; more common south.

Difficult to differentiate in the field from **A. flavoconia** and **A. flavorubens** which are also yellow with a yellow veil. The non-amyloid spores is the most distinctive feature.

10. **A. wellsii** Murrill

Medium species; cap salmon or pink colored, covered with yellow particules or flakes which are often fugacious, margin forming a sterile edge and appendiculate with debris of the veil, distinctly striate at the end; gills pale yellow, with yellow particules on the edge; stipe bulbous, pulverulent or floccose pale yellow; annulus delicate and fugacious, yellow; volva floccose, yellow, spores elliptical.

Occasional in deciduous woods.

This beautiful pink and pulverulent amanita is only known in the northeast. We have identified entity found in Quebec and in northern New Hampshire as **A. parcivolvata** (Peck) Gilbert, a species occuring in North Carolina. The latter is also reddish and powdery with yellow particules and devoid of an annulus, but the margin is strongly striate and pyramidal warts are often found on the cap. Therefore, the name **A. wellsii** should be retained for the pink amanita found in the northeast.

11. **A. gemmata** (Fries) Gilbert

Small and medium species; cap yellow, cream color, drab or whitish, adorned with a few white floccose patches, and with a margin sulcate or striate; stipe with a globular bulb and a fugacious annulus; volva floccose, fragile, white, forming a ring or a crown above the bulb and leaging patches on the stipe; spores oval or elliptical.

Cosmopolitan and common in mixed and conifer wood.

This is a complex species with several forms that have reveived various names: **A. junquillea, A. crenulata, A. recutita,** and **A. russuloides.**

12. **A. muscaria** Persoon ex Hooker

Cap usually orange or orange yellow, occasionally deep red when young, rarely white, covered with yellowish or white floccose warts, margin sulcate; gills white; stipe long, with an oval bulb and a large white and membranous annulus, adorned with concentric rings or fluffy scales; volva floccose and evanescent; spores elliptical.

Cosmopolitan and very common in mixed and conifer woods. Poisonous.

The most common form in eastern America appears to be different from the European one by the color of the cap which is deep red in Europe, however, extensive variations in color have been also noted in Europe (Romagnesi, 1956; Cerruti, 1948).

13. **A. cothurnata** Atkinson

Large and medium species; cap olivaceous brown, paler toward margin, sometimes white with a cream colored disc, ornated with pyramidal warts or with large white patches, sulcate on the margin; stipe slender with a round, oval or pointed bulb, adorned above the bulb with concentric collars; annulus white, pendant, large; volva floccose sheating on the bulb; spores elliptical.

Occasional during summer in deciduous woods, mainly under oaks.

The identity of the American species with its pale olivaceous brown or white cap, is also a problem. Whether it is a distinct species from the European **A. pantherina,** with a "bister brown" cap remains to be established. **A. velatipes** Atkinson is only a form of **A. cothurnata** and not of **A. gemmata.**

OTHER SPECIES

A. pubescens Schweinitz

A rather small and rare species found in the Carolinas which seems to be a form of **A. cothurnata.**

Section AMIDELLA

Stipe with or without an annulus; cap smooth or with debris of the inner part of the double veil; volva thick and sheating; spores elliptical, amyloid.

14. **A. peckiana** Kauffman

Medium species; cap white with floccose or mealy particules, margin smooth and often with lacerated debris of the veil; stipe stout, white, with a large bulb made of a thick volva; annulus fugacious; spores cylindrical, amyloid; pyriform cells on the edge of the gills.

Very rare in sandy soil, under eastern white pine.

This very distinctive species, with its cylindrical and amyloid spores, and its thick volva, which includes part of the bulb, belongs to the section which includes the European **A. ovoidea.**

15. **A. volvata** (Peck) Martin. = (**A. agglutinata** (B. & C.)Lloyd

Medium species; cap reddish brown or whitish, scaly and often with patches of the reddish brown veil and with dusty debris at the striate margin; gills whitish, becoming brownish; stipe whitish, becoming brown stained when touched; bulbous at the base, without annulus or with debris of the partial veil; volva ample, saccate, white, then brownish; spores elliptical, amyloid.

Rare in deciduous woods.

This species is well characterized by its scaly cap and its persistent brown veil.

OTHER SPECIES

A. abruptiformis Murrill might be a form of **A. volvata; A. roanokensis** Coker et **A. mutabilis** Beardslee are close to **A. peckiana.**

Section PHALLOIDAE (Fries) Quélet

Annulate stipe with a round bulb; volva membranous, persistent, saccate; cap bare or with large patches of the veil; spores oval or elliptical. Deadly poisonous species.

16. **A. virosa** (Fries) Quélet

Medium to large species; cap conical, then campanulate and umbonate, white, smooth, sometimes with a large patch of the veil; stipe long, white, fibrillose or squamulose, with a membranous and fragile annulus and a globular bulb; volva membranous, saccate at the base of the stipe and separable from the bulb; spores globular or oval.

Frequent in mixed and deciduous woods.

This deadly poisonous species is pure white and distinctive by its conical or campanulate cap. It is probably responsible for most of the phalloidian intoxication in North America.

17. **A. bisporigera** Atkinsoh = (**A. verna** var. **bisporigera** (Atk.) Coker)

Small or medium species; cap convex, white, smooth, often with a patch of the white veil; stipe slender, cylindrical, white, with a short and round bulb and a membranous annulus; volva membranous, adhering to the bulb; spores spherical; basidia 2- to 4-spored.

Rather frequent in deciduous woods.

Also deadly poisonous, this species differs from **A. virosa** and **A. verna** by its small size, its slender stipe with a little round bulb, and its 2-spored basidia. **A. tenuifolia** Murrill is seemingly a synonym.

OTHER SPECIES

A. phalloides, the green deadly poisonous species of Europe does not occur in eastern North America. It has been mentioned on the West Coast, but this remains to be ascertained.

A. magnivelaris Peck, considered by Gilbert as a form of **A. verna,** is probably a good and distinctive species. **A. gwyniana** Coker may be a form of **A. magnivelaris,** and **A. elliptosperma** Atkinson is probably similar. Concerning the occurrence of **A. verna** in North America, more studies remain to be done to accept this name.

Section MAPPAE

Stipe with a large marginate bulb; cap warty; volva floccose or semi-membranous, adhering to the bulb; spores globular, amyloid.

18. **A. brunnescens** Atkinson

Large or medium species; cap conical, then campanulate, viscid, olivacious brown, paler toward margin, with innate dark fibrills, and covered with a few warts or patches of the grayish or white veil; stipe stout, enlarging toward the base and terminated by a large and marginate bulb, usually split 3 or 4 times,

whitish, becoming brownish, provided with a white, membranous and ample annulus; spores globular.

Common in mixed and deciduous woods.

This entity has been known for a long time as the American form of the European **A. phalloides.** It belongs to a different section and does not contain amanitatoxin. Obviously it is a close relative to the two following species. **A. brunnescens** var. **pallida** has no taxonomic value.

19. **A. citrina** S. F. Gray

Small and medium species; cap convex, almost white to lemon yellow, with a few patches or warts from the white veil, viscid; flesh white, with a strong odor of raw potato or radish; stipe white, with a yellowish, pendant annulus and a large marginate bulb; volva membranous, forming a narrow rim on the bulb; spores globular.

Cosmopolitan species, frequently found in mixed and deciduous woods.

Formerly known as **A. mappa** (Fries) Quélet, it has been considered poisonous. It is not so but only disagreeable. This species is distinctive by its light yellow cap, its odor of radish and its marginate bulb.

20. **A. porphyria** (Fries) Secretan

Small and medium species; cap viscid, bister brown or grayish brown, sometimes with a purplish or lilac hue, with innate fibrills and covered with powdery or floccose debris of the veil; flesh whitish, with a slight odor of radish; stipe slender or short, with a membranous and pendant annulus becoming black, and terminated by a large marginate bulb, with ashy fibrills below the annulus;

Common in mixed and deciduous woods, cosmopolitan. Disagreeable.

Two forms are known in North America; a small one with a viscid and purplish brown cap and a middle-size one with a gray pulverulent cap, sometimes called **A. tomentella** Krombholz. The circumscissile volva around the bulb has no taxonomical value since all intermediate forms occur in the same areas.

Section AMPLARIELLA Gilbert

Stipe with a membranous and pendant annulus and a non-marginated bulb which is often pointed below; volva floccose, fugacious, cap smooth at the margin, with floccose warts or patches; spores elliptical and amyloid.

21. **A. rubescens** S. F. Gray

Medium or large species; cap campanulate, whitish or brownish, becoming reddish tinged, covered with grayish and floccose warts; flesh whitish, reddish when broken, particularly at the base of the stipe; stipe stout, with a membranous, ample, white or red stained annulus, and with a non-marginated bulb marked by one or two rows of dark spots; volva floccose; spores elliptical.

Common in deciduous, mixed and coniferous woods.

This cosmopolitan species is well known and frequently eaten. It is often deformed by a parasite; **Hypomyces hyalinus** (Sch.) Tulasne.

22. **A. flavorubens** Berkeley and Motagne

Small and medium species; cap yellow and brownish on the disc, with pyramidal, floccose and yellow warts; stipe with a more or less well marked bulb, and with patches of the yellow veil; flesh at the base of the stipe reddish or madera brown; spores ovales or elliptical.

Occasional in mixed and deciduous woods.

Sometimes considered dangerous, but this is not certain. This species is characterized by the reddish color of the flesh at the base of the stipe. It is often mistaken for **A. frostiana** or **A. flavoconia** also provided with a yellow floccose veil.

23. **A. flavoconia** Atkinson

Small and medium species; cap chrome yellow or orange yellow, with yellow and floccose warts; stipe with a membranous and yellow annulus and a small round bulb; volva yellow floccose, leaving patches on the stipe and the bulb; spores oval to elliptical.

Common in mixed and coniferous woods.

This small species with a yellow floccose veil differs from **A. flavorubens** by the unchanging color of the flesh and from **A. frostiana** by its amyloid spores. **Hypomyces hyalinus** is also parasitic on this species.

A. spissa (Fries) Kummer

Medium size species; cap bister brown with grayish warts or large patches of the floccose or pulverulent veil; flesh white, with anis or radish odor; stipe with a rather large bulb, fibrillose or squamulose, whitish or grayish; annulus ample, white, grayish below; spores elliptical.

Rare in Quebec in deciduous and mixed woods.

This bister brown amanita has received several names in Europe and here. **A. ampla** Persoon includes: **valida, cinerea, cariosa** and **excelsa.**

OTHER SPECIES

A. excelsa (Fries) Kummer

Medium to large species; cap whitish to pale brownish, with pyramidal warts or flocculence, margin somewhat striulate; stipe slender, with a bulb more or less well marked, whitish and with flocculence; volva fragile and often disapearing.

In mixed and grondose woods.

We have seen this form in Massachusetts, **A. morrisii** Peck and **submaculata** Peck are probably synonymous names of **A. excelsa** or **A. spissa.**

Section LEPIDELLA = (ASPIDELLA Gilbert)

Stipe usually with a large, napiform or radicating bulb and a membranous annulus; cap with a projecting or appendiculate margin; veil thick, leaving pyramidal warts on the cap and flocculence on the stipe; spores elliptical and amyloid.

25. **A. atkinsoniana** Coker

Medium to large species; cap pale brown or whitish, covered with numerous pyramidal warts, flocculent toward margin which is projecting and fringed; stipe stout with a napiform or more or less radicating bulb which is ornated with rows of brown scales; annulus floccose and fugaceous; flesh white or rosy, with a more or less strong odor of chlorine; spores elliptical, amyloid.

Rare in certain oak stands.

This beautiful amanita is well characterized. The collections made every year near Quebec city correspond with the description and photos of Coker from material found in the Carolinas. Also known in Massachussetts and Michigan.

26. **A. onusta** (Howe) Saccardo (?)

Small to medium species; cap covered with floccose or dusty particules or warts which are grayish toward the center, margin appendiculate; flesh with a strong odor of chlorine; stipe whitish, flocculent, with a fugaceous annulus and a long radicating bulb; spores elliptical and amyloid.

Rare in mixed and deciduous woods.

According to Bas, the name **A. cinereoconia** should be applied to a small amanita found in Virginia and south and not to a entity collected in New England and in Quebec. Although uncertain, the name **A. onusta** should be

A. chlorinosma (Austin) Lloyd

Medium to very large species; cap subglobose to convex, white to cream color, covered with a dense white flocculence or meal, with an appendiculate margin; flesh with a strong odor of chlorine; stipe long, with a more or less rooting bulb, covered with flocculent remnants of the volva; annulus fragile and lacerated; volva floccose, and variously attached to the bulb and the stipe; spores elliptical.

Occasional in deciduous woods. Not found in Quebec.

This very large and white flocculent species, with a strong odor of chlorine is well characterized, but has been mistaken with other entities. Gilbert and more recently Bas have traced its limits.

A. cokeri (Gilbert and Kűhner) Gilbert

Very large species; cap globular and convex, with appendiculate margin white to ivory, ornated with white pyramidal warts; stem long, with a large rooting bulb, covered with pyramidal warts or recurved scales; annulus pendant ample, membranous, double, white; flesh with no odor of chlorine; spores elliptical.

This remarkable amanita has been called **A. solitaria** by several authors, but its identity has been established by Gilbert and Kűhner and confirmed by Bas.

A. ravenellii (Berkeley and Curtis) Sacc.

Very large species; cap hemispherical, covered with coarse, conical brownish warts, and toward the margin with fibrillose scales; stipe with a large rooting bulb, covered with flocculence and scales; annulus thick, flocculose; odor strong of chlorine.

This amanita was commonly known in the U. S. A. under the name of **A. strobiliformis** which is a European species.

A. abrupta Peck

Medium size species; cap hemispherical, pure white, covered with small conical warts, appendiculate at the margin; stipe slender, white, flocculent-fibrous, with a large, abrupt and non-rooting bulb; annulus pendant, ample, membranous, white; flesh odorless; spores globular to elliptic.

An elegant and very distinctive white amanita occuring in southeastern U. S. A.

A. rhopalopus Bas

Medium to very large species; cap hemispherical, whitish to grayish white, covered with floccose patches of the veil forming irregular conical warts toward the center, with floccose-fibrillose remnants at the margin; stipe long, with a long, deeply rooting, cylindrical or fusiform bulb, covered with flocculence or floccose warts; annulus fibrillose-floccose, fugacious; spores elliptic to oval; flesh with a strong smell of chlorine.

This large rooting amanita, occuring in central eastern states, has been called **A. solitaria** a species which does not exist in North America.

A. mirolepis Bas

Medium to large species; cap convex, dingy cream colored, adorned with very small floccose warts; stipe with a napiform or globose bulb, whitish to cream, appressedly fibrillose-squamulose and with rings of small warts; annulus membranous, broad, whitish; flesh with a strong odor of chlorine; spores elliptic.

This is another amanita with a chlorine smell found in central eastern U. S. A., that has been mistaken for **A. chlorinosma.**

A. polyramis (Berkeley and Curtis) Sacc.

Large species; cap convex, white, with white pulverulence and conical warts, appendiculate at the margin; stipe long, with a large subglobose napiform bulb, white, pulverulent, with several rings of small warts; annulus thick, fragile, white; odor of chlorine.

This new species, collected from Maryland to Florida, has also been mistaken for **A. chlorinosma.**

A. daucipes (Montagne) Lloyd

Medium to large species; cap convex, whitish to pale orange or red-brown, densely covered with spinulose or conical warts, or flocculence toward margin which is appendiculate; stipe whitish to salmon color, with a fusiform or napiform bulb which is marginate or submarginate, flocculent all over; annulus delicate, pendant yellowish to red-brown; odor nauseous; spores elliptic.

This is another species from central eastern U. S. A. that has been mistaken for **A. chlorinosma.**

A. cinereoconia Atkinson

Small to medium species; cap convex to flat, whitish to grayish, with pulverulence or pulverulent warts; stipe equal, with a napiform or fusiform bulb, white, to grayish, floccose-pulverulent; annulus rarely visible, the partial veil being pulverulent; odor of chlorine; spores elliptic to cylindrical.

This small species of central eastern states is apparently different from the entity that we have named **cinereoconia** which should be called **onusta** according to Bas.

A. pelioma Bas

Described under the name **A. chlorinosma** by Coker, this amanita is different by its grayish-olivaceous buff color and several microscopical features. It has been found only in North Carolina and Tennessee.

A. westii Murrill

This medium size species has been collected only once in Florida.

A. subsolitaria (Murrill) Murrill

Another amanita collected only once in Florida.

A. solitariiformis (Murrill) Murrill

Collected twice in Florida.

A. rhoadsii (Murrill) Murrill

This amanita, with a strongly pulverulent-flocculose cap, adorned with large conical warts when young, and with a deeply rooting fusiform or napiform bulb, is more frequent in south eastern states.

A. cinereopannosa Bas

Medium to very large species; cap convex, whitish to smoky buff, with scattered felty warts or patches; stipe subcylindrical, with a fusiform, slightly rooting bulb, fibrillose-lacerate, brownish gray; annulus fugaceous grayish; odor slight.

Collected under pines, from Massachusetts to North Carolina. It is a well characterized species.

A. limbatula Bas, **A. praelongispora** (Murrill) Murrill, **A. parva** (Murrill) Murrill

These three species of small amanitas, rarely collected from New York State to Florida, are characterized by microscopical features.

A. mutabilis Neardslee

A medium size species with a white cap bearing whitish patches, and with a napiform and marginate bulb at the base of the stipe, has been found rarely in North Carolina and Florida.

A. roanokensis Coker, **A. inodora** (Murrill) Bas and **A. alliacea** (Murrill) Murrill

These three closely related species, collected in the Carolinas and Florida, are mainly characterized by their long bacilliform spores.

A. hesleri Bas

A distinctive species, found twice in North Carolina and in Tennessee, is characterized by the gray-brown to dark gray fibrillose scales on the dry cap.

A. praegraveolens (Murrill) Singer

A large species with a strong odor and a white to pinkish cap, collected rarely in Florida.

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KEY TO NORTHWEST MUSHROOMS

AMANITAS

Puget Sound Mycological Society

By permission of P.S.M.S.

Anyone who collects mushrooms to eat should learn to recognize the genus **Amanita**, so that he can avoid all of its species. This is not too difficult, as most of them are rather conspicuous mushrooms.

Amanita pantherina

Amanitas have four distinguishing features which are usually fairly obvious – namely, volva, ring, white spores and free gills. The first and most important of these, the so-called "death cup" or volva, is a thimble-like or sack-like structure at the base of the stem, formed in the following way. The very young, unexpanded "button" stage of an Amanita is completely enclosed in a layer of tissue called the universal veil. As the mushroom grows, the universal veil is ruptured, part of it remaining at the base of the stem to form the volva, the rest being carried up on the surface of the cap, where it breaks into small patches as the cap expands. Sometimes all of the universal veil remains at the base of the stem to form a large, sack-like volva, in which case the surface of the cap will be devoid of patches. Another layer of tissue extends from the margin of the cap to the stem, pulling away from the margin as the cap expands, and collapsing upon the stem to form the characteristic pendent, skirt-like ring. The ring is well developed in most Amanitas, but is lacking in some species.

The other two distinguishing features, white spores and free gills, are not difficult to recognize. Free gills are gills that do not quite reach the top of the stem; in case of doubt, if the mushroom is split lengthwise down the middle, the relation of the gills to the top of the stem is easily seen. The color of the spores can be determined from a spore print, following the directions to be found in

the introductory pages of almost any mushroom handbook. It is important to remember that an Amanita is characterized by the **combination** of the features just discussed. Very many kinds of mushrooms other than Amanitas have white spores, many have a ring, some have free gills, and a few have a volva, but the combination of volva, free gills, and white spores (with or without a ring) occurs only in Amanita.

Amanitas are to be found at any time of year when conditions are favorable for the growth of mushrooms. You will meet them far more frequently in the forest than outside of it, and most of ours seem to prefer growing under or near conifers. The ten species presented in the key are the ones most frequently found here; they range throughout western Washington, Oregon and British Columbia. The two that predominate in most localities are **pantherina** and **muscaria.** Both normally have the cap covered with white, wart-like patches, on a brown surface in **pantherina** and on a yellow, orange or red surface in **muscaria.** They are easy to recognize, hence easy to avoid. Fortunately for us, the rarest Amanita in the Pacific Northwest is **verna,** the beautiful, pure white "Destroying Angel", responsible for so many fatal cases of poisoning in North America and Europe. It has only recently been found in Washington, thus far in just one locality. Let us hope it does not find our climate and our forests to its liking.

It is true that there are some edible Amanitas, but they are too easily confused with the poisonous species to risk eating them. The wise mushroom hunter will shun anything that he even suspects might be an Amanita; with so many good, easily recognizable edible mushrooms growing all around, why take chances?

HOW TO USE THE KEY FOR IDENTIFICATION

Note that at the left of the column, the numbers are arranged in pairs.

Starting with number 1, read both descriptions, choosing the one which fits the unknown.

Note accompanying number at the right.

Find this same number at the left of the column farther down, which appears as another pair.

Again choose the description which fits. Note accompanying number at the right, and repeat the process until the name is given.

1. Volva saccate (see illustration) 2
1. Volva not saccate (see illustration) 4
2. Ring present 3
2. Ring absent – cap lead colored . . . . . **A. vaginata**

   A. vaginata – cap 1½ to 4 inches across, first rounded eventually flat, with grooved lines around the edge. Stem white, slender, 3 to 4 inches in length, base deep in the soil. The saccate volva envelops the young fruiting body in an egg-shaped form. Usually found in, or on the edge of coniferous woods.

3. Entire mushroom white . . . . . **A. verna (A. virosa)**

   A. verna (A. virosa) "Destroying Angel" – Cap pure white and sticky to touch, first rounded, eventually flat, 4 to 12 inches across. Stem 4 to 10 inches in length. This very deadly mushroom was identified in May of 1968 near Battleground, Washington.

   Amanita phalloides, which is the most dangerous of the genus and found in both coniferous and hardwood forests, has not yet been found in the Northwest. It is greenish yellow to greenish brown, sticky capped, 5 to 6 inches across, with ringed white stem and saccate volva on a bulbous base.

3. Cap yellow or orange – often with large part of veil on cap . . . . . **A. calyptroderma**

   A. calyptrodima – Cap first rounded then broadly expanded, smooth, except for pieces of veil stuck to it, sticky with etched lines on the margin, 2 to 12 inches across. Gills creamy-white to yellowish. Stem creamy-white, short, rising from a large, white felty cup (volva). Found in mixed woods in fall.

4. (1) Entire mushroom white 5
4. (1) At least cap not white 6
5. Bulb tapering downward in carrot shape. Stem two or more times as long as cap width, often smells of chlorine . . . . . **A. solitaria**

   A. solitaria – Cap pinkish

5. Not as above – stem short – slight ring . . . . . **A. silvicola**

   A. silvicola "Woodland Amanita" – Cap rounded, then flat 3 to 4 inches across, dry and often fluffy with remains of universal veil. Gills white. Stem white, short, bulbous base showing fluffy remains of volva but no distinct cup. Found in coniferous woods or along their edges in fall.

6. Cap yellow 7
6. Cap not yellow 8
7. Volva with single distinct edge . . . . . **A. gemmata (A. junquillea)**

A. gemmata (A. junquillea) — Cap pale yellow, not changing significantly in color as it matures; pieces of universal veil, white to cinnamon in age, scattered over surface, often of large size, but these may be washed off in a rain, 3 to 4 inches across, finally flat, surface sticky. Gills white to cream color. Stem 4 to 5 inches long, one inch or more in diameter, with ring, base bulbous and volva distinct as in **A. pantherina.**

7. Volva with several concentric rings . . . . . **A. muscaria**
(yellow form-sometimes tan)

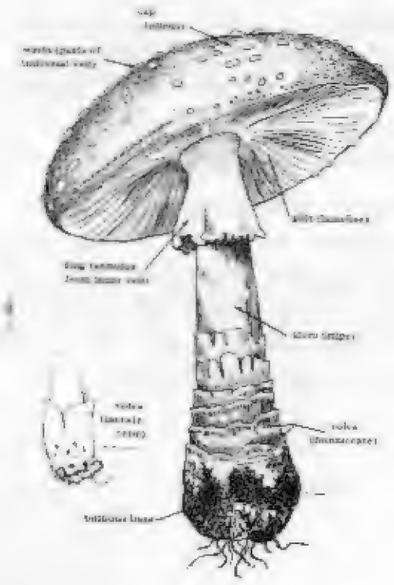
8. Cap red or orange . . . . . **A. muscaria**

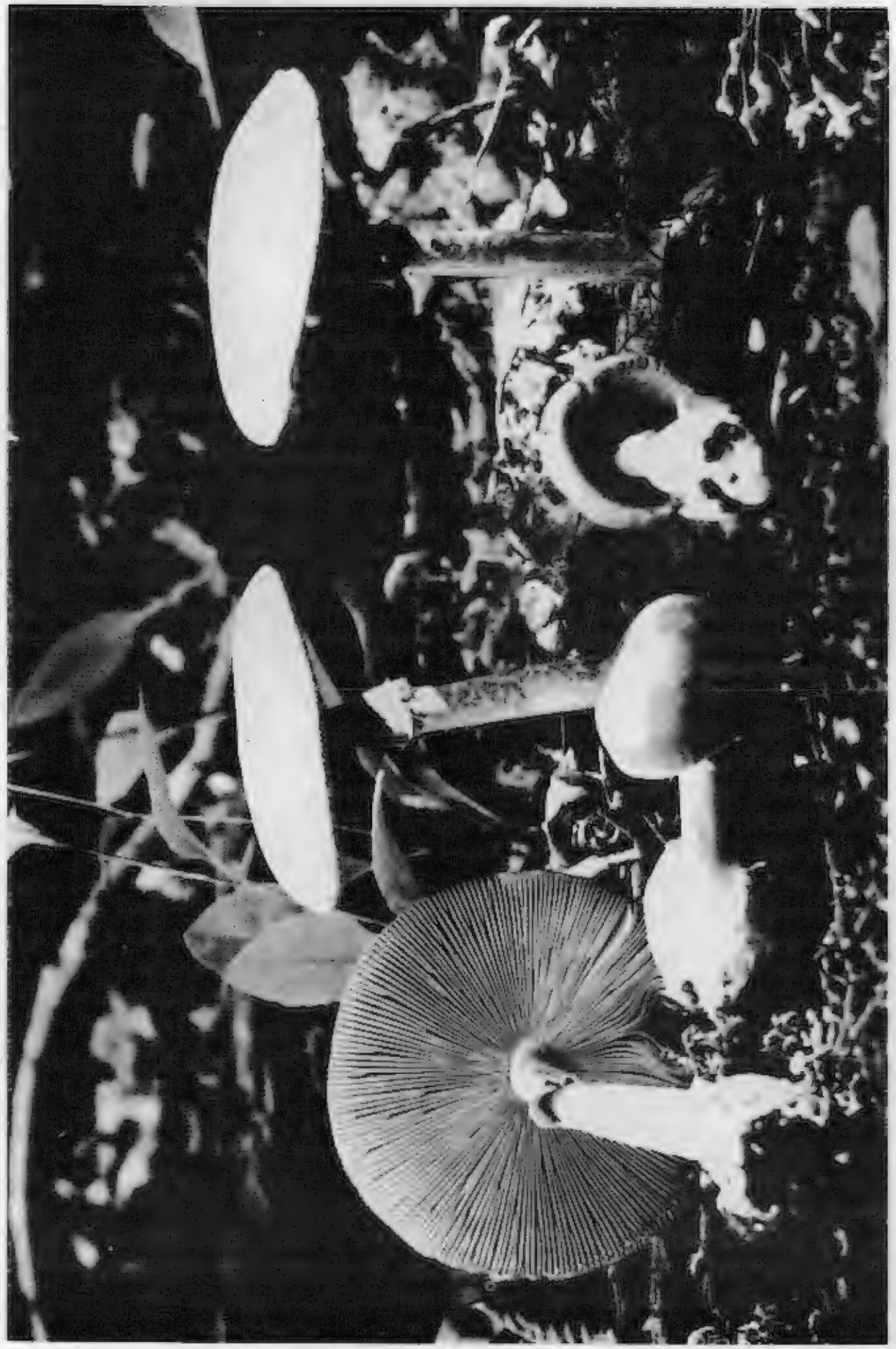
A. muscaria "Fly Amanita" — Cap brilliant red or orange, sometimes yellow, tan or rarely white; pieces of the veil are scattered over the surface like cottage cheese; 3 to 12 inches across. Gills white to cream white. Stem white, with ring, bulbous base. Found in coniferous woods in fall, sometimes spring. Dangerous but not often fatal.

8. Cap brown — Grayish brown with purple tinge — warts few, smooth 2 to 4 inches across — stem white with grayish patches — base flared to flattish shoulders with wide cracks, volva may have flap free on one side — gray ring — no yellow color anywhere — potato sprout odor. . . **A. porphyria**

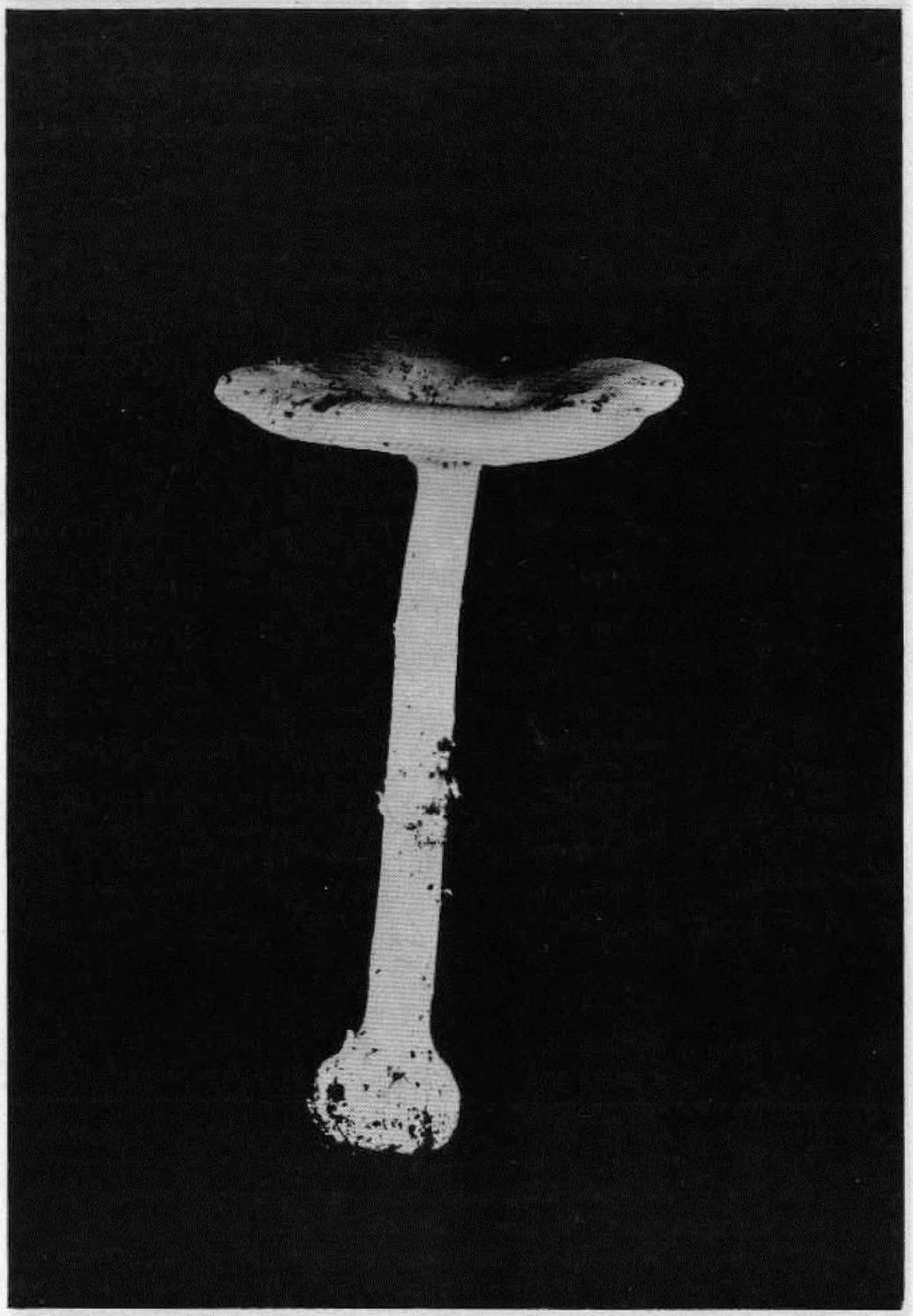
— Tan to dark brown, 4 to 12 inches across, sticky — warts plentiful and white — Stem white, with ring — volva with distinct rolled edge — very poisonous — found under Douglas Fir, mostly in the fall . . . . . **A. pantherina**

— Dark brown to black, 2 to 4 inches across, sticky — warts gray — stem 3 to 5 inches long, yellowish above ring — ring gray with yellow margin — found under conifers in the fall . . . . . **A. aspera**

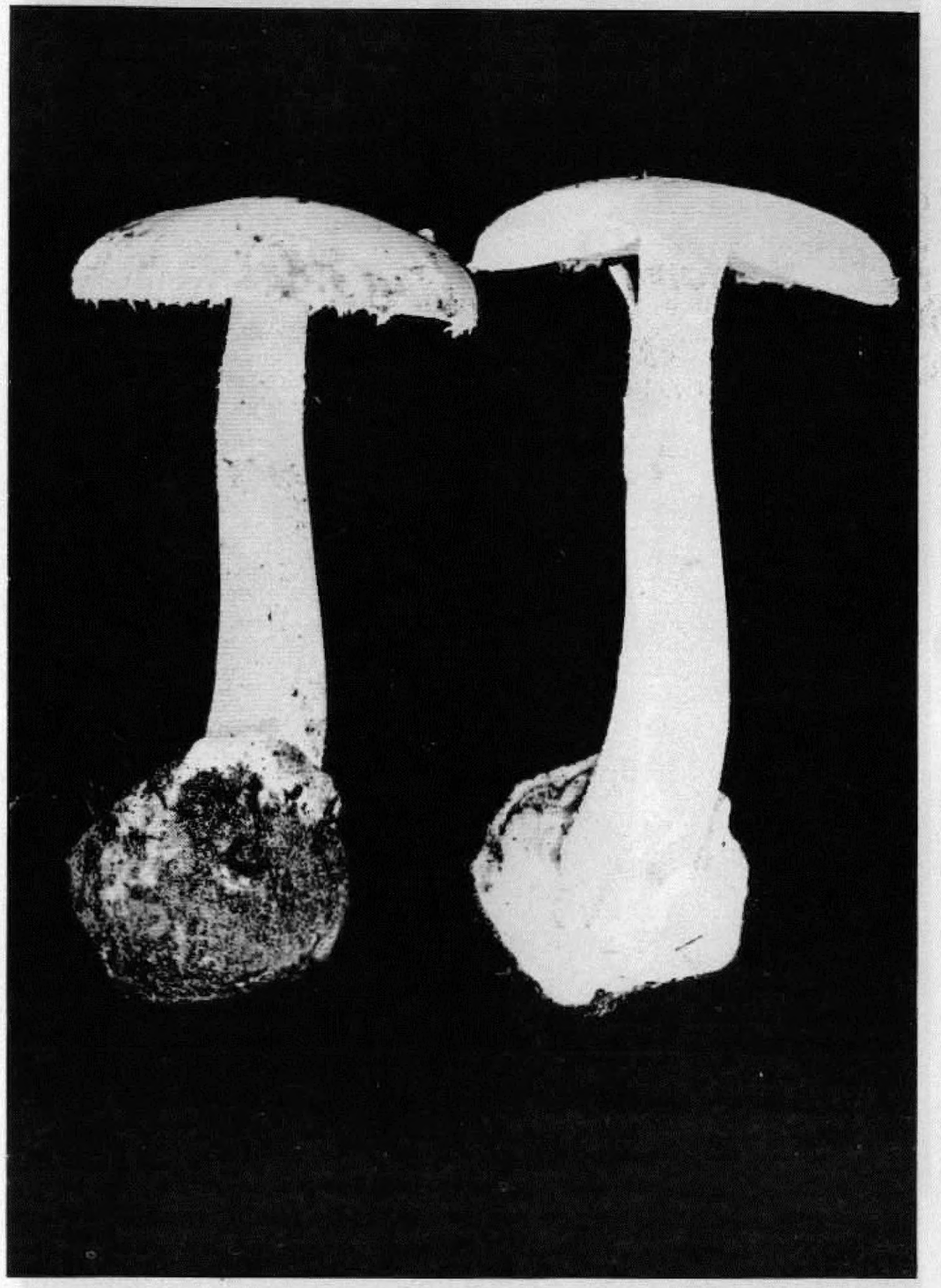




A. CAESAREA (6)

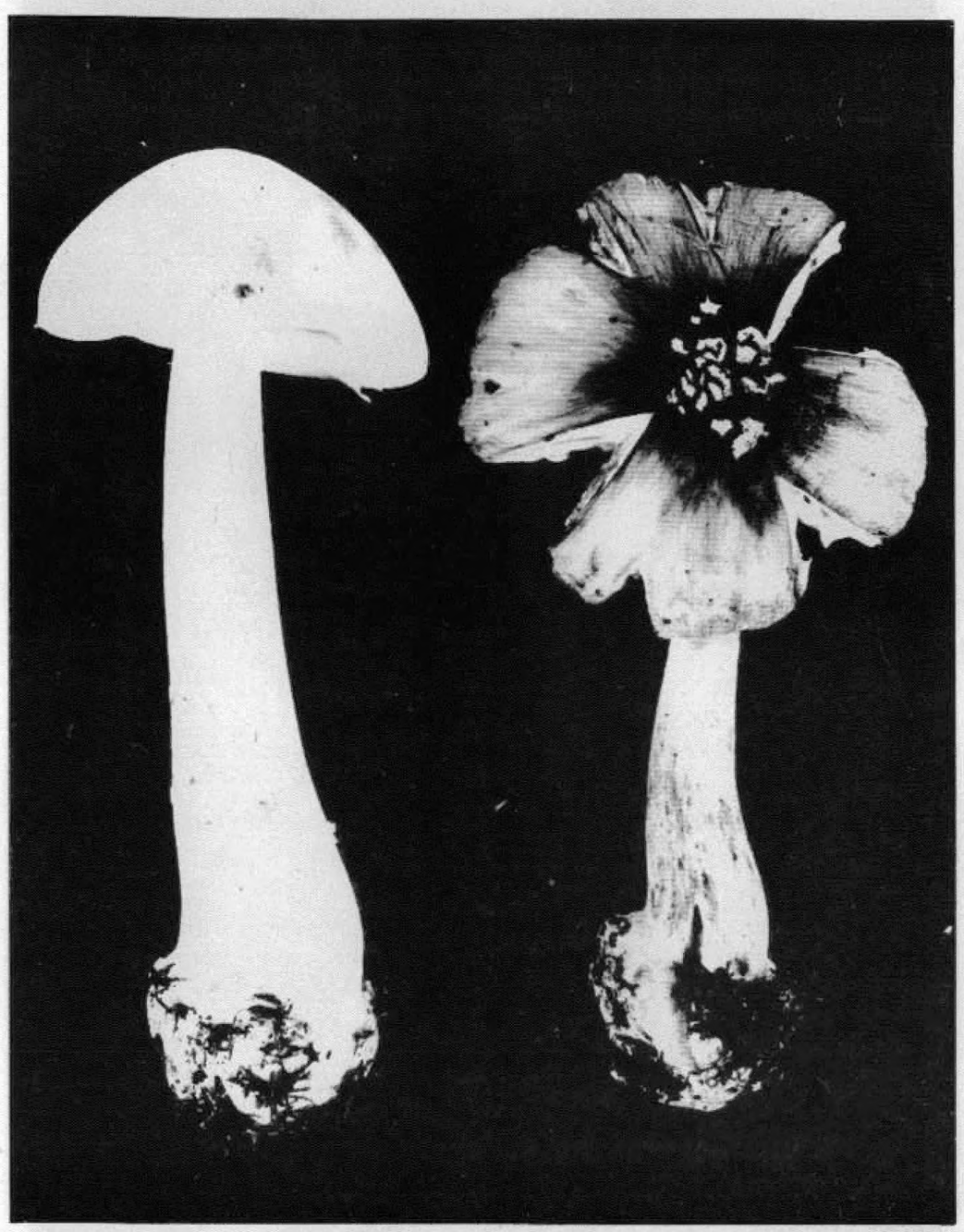


A. GEMMATA (11)

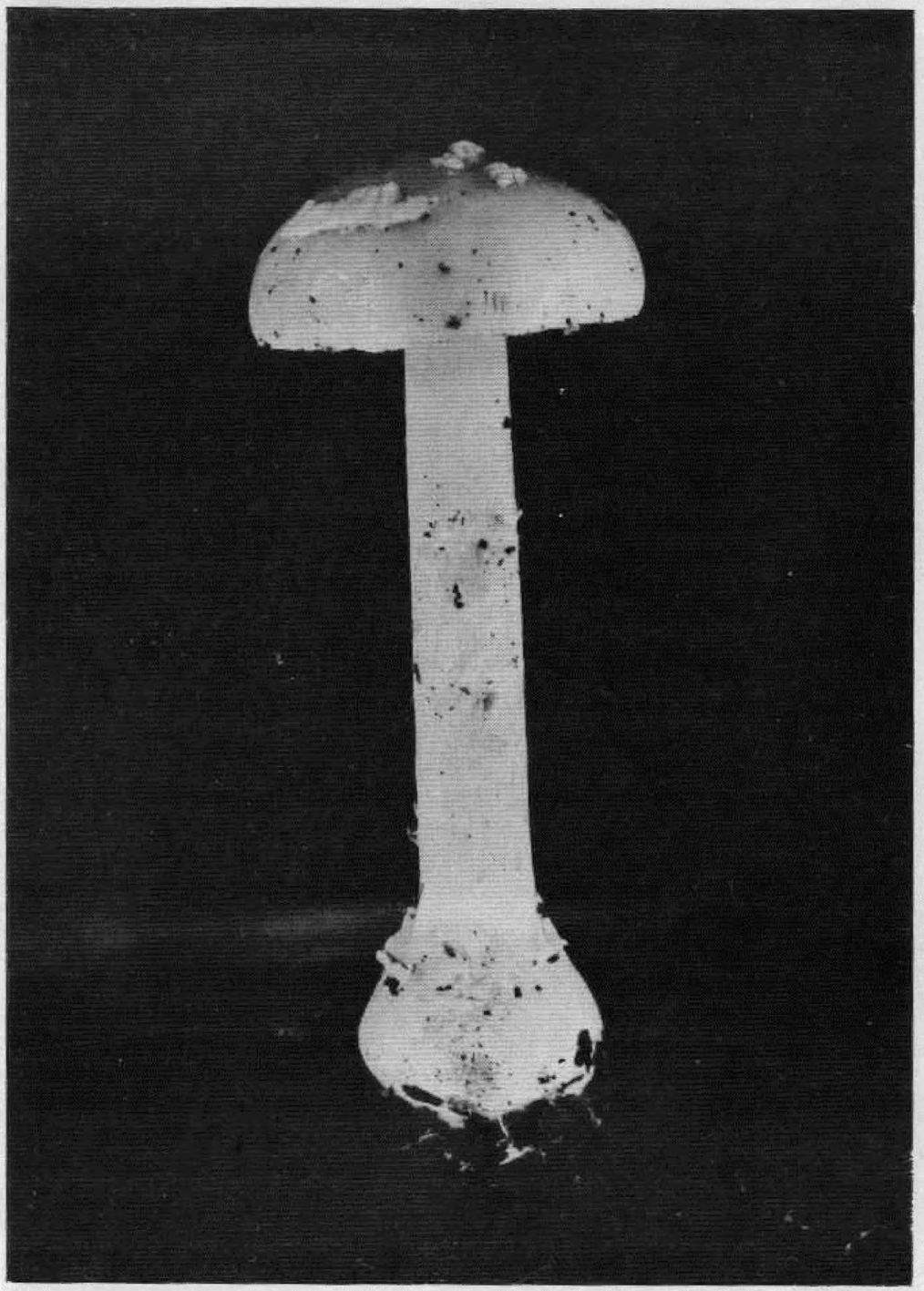


A. PEKIANA (14)

A. VIROSA (16)

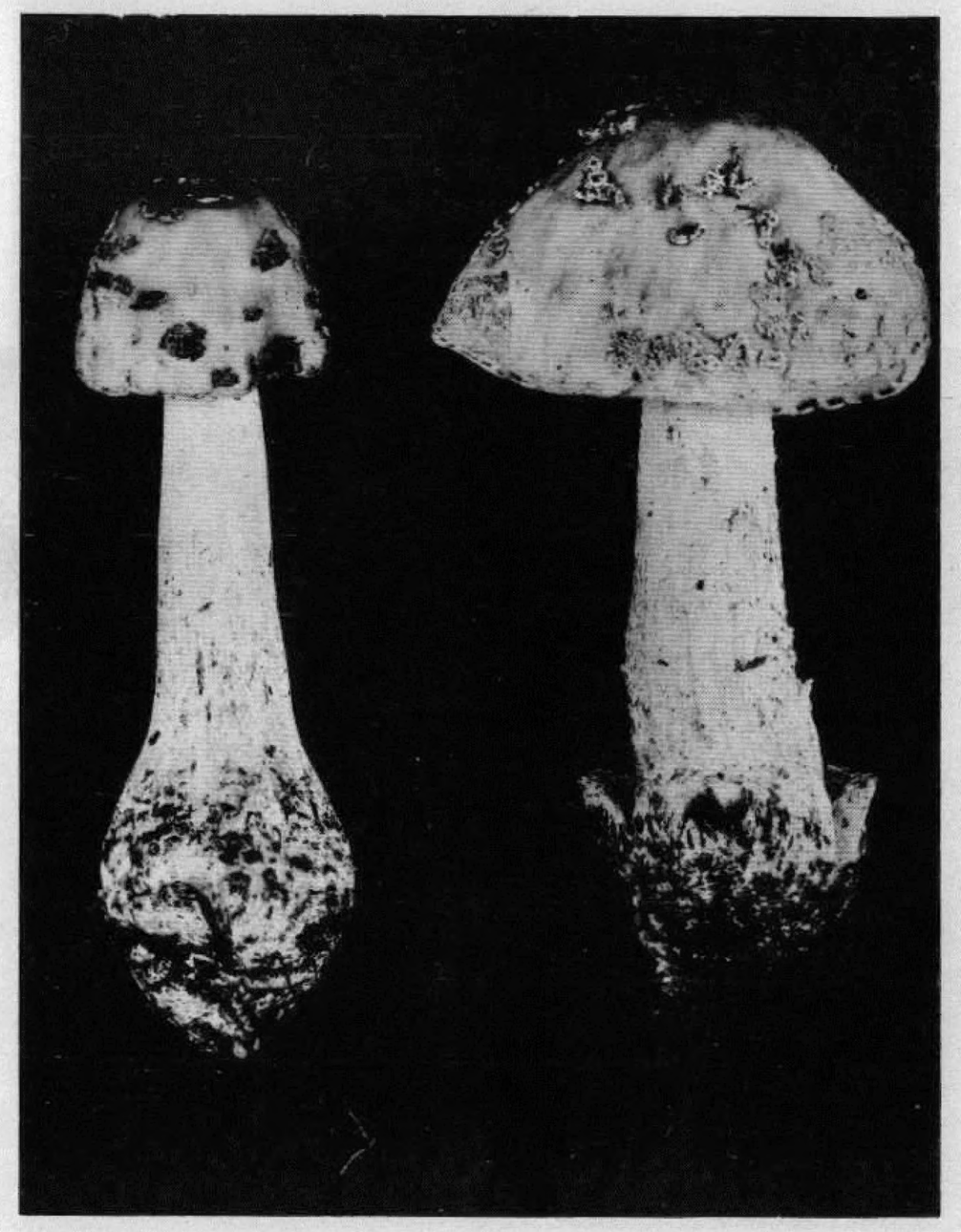


A. BRUNNESCENS (18)



A. CITRINA (19)

A. PORPHYRIA (20)



A. RUBESCENS (21)